The railroad pocket-book

Fred Herbert
Colvin

RRs-Equipment

The Railroad Pocket-Book

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A quick reference cyclopedia of railroad information

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by

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PREFACE.

This little book has been prepared to give some of the information constantly called for different branches of the railroad service. No book of the kind can ever be complete, as new devices are constantly being brought out—older ones are being changed and practice and theories vary.

It is intended to give such information as is needed along different lines, in a brief but clear manner, to have them in handy form and easily found when wanted. To this end the whole book has been alphabetically arranged and the index abandoned as useless and confusing. All air brake matter is again divided alphabetically under Air Brake as being more convenient than having it scattered all through the book.

Suggestions, additional data, and any information which the reader feels would make the book more helpful will be thankfully received and errors gladly corrected.

Acknowledgement is due numerous catalogs, trade papers and other sources of information.

Hoping for your co-operation.

THE AUTHOR.

A

Absolute Zero.—This point is 460 degrees (Fahr.) below zero, or 492 degrees below the freezing point.

Acceleration of Falling Bodies.—A body falling from a height, through space, falls 16.1 feet the first second, 48.3 feet the second and continues falling with an increased velocity of 32.2 feet per second. To find velocity at the end of any second, multiply the seconds it has been falling by 32.2 and subtract 16.1 from answer.

Acceleration of Piston.—The increase from lower to higher speed or from rest (at the end of stroke) to highest speed at or near the center of cylinder. The heavier the piston or other reciprocating parts, the greater energy required to stop and start it.

Acceleration of Reciprocating Parts.—See Acceleration of piston. Same thing applies to all reciprocating parts.

Acceleration of Speed.—Increasing from lower to higher speed. This requires additional power, and is calculated as follows: Subtract the square of the initial speed from the square of the higher or attained speed, and multiply by .0132, which gives increased resistance in pounds per ton. Example: Train running at 10 miles per hour and accelerates to 25 miles per hour. What is resistance per ton? $10 \times 10 = 100$. $25 \times 25 = 625$. Subtracting 100 leaves 525, and multiplying by $.0132 = 6.93$ additional resistance per ton. This is for acceleration in one mile on straight, level track.

Acetylene Headlights.—The production of acetylene gas is the result of bringing calcium carbide into contact with water. This generates a gas which gives a brilliant white light, is not so hot as coal or oil gas, and is not expensive. There are two methods of control. One feeds the water on to the carbide, and the other uses granulated carbide and drops it into the water. A modification of this carries the carbide on a perforated plate and lowers it into contact with the water. The accumulation of a pressure of gas raises it out of the water. There are a number of machines on the market for making this gas, both for headlights and car lighting. Among them are the "Dorothy" (Giles Cook).

They consist essentially of a tank or vessel for carbide, a water tank and a gas chamber, although some combine these in various ways, and the valves necessary for control. The Dorothy has its carbide vessel at the bottom, this being 8½ inches in diameter and 8 inches high. Over this is a pair of tanks 7 inches in diameter and 18 inches high—one for water, the other for gas. These are connected so as to feed water to the carbide at

the rate of about two quarts an hour, as a pint of water generates about 10 cubic feet of gas. An accumulation of gas closes the water supply, and controls its generation.

Acetylene Lighting.—One of the newer systems of acetylene lighting is that of the Commercial Acetylene Company, which apparently has many advantages. It is a storage system, no gas being generated on or in the car, and the claims are rather startling.

A tank of the usual form is used, filling about 1-5 of it with an asbestos, or, rather, porous brick. Four-sevenths of the volume is now filled with acetone, a liquid distilled from wood, and on the order of alcohol. The acetylene gas is now pumped into the tank to the desired pressure, 10 atmospheres, or 147 pounds, being a very common pressure. The gas is absorbed or dissolved by the acetone, and, strange to say, it increases the capacity of the tank tenfold. As the gas only burns at ¼ the rate of ordinary gas, it will be seen that the capacity is again multiplied by 4.

Gas tanks of the ordinary size for car lighting are 10 feet 4 inches long, and 19½ inches in diameter, holding 21.5 cubic feet. This is claimed to hold 2150 cubic feet of acetylene gas at 10 atmospheres, and to give over 200 hours' light for an ordinary car. Counting 4 hours a day as the average light for a car, this gives over 50 days' light for one charging of the tank.

Experiments seem to show that the acetylene gas stored in or absorbed by acetone cannot be exploded by shock or heat. Cold does not destroy it, and in fact it seems to present many desirable features.

Acre.—43560 square feet

A square of $208\frac{71}{100}$ = acre

A square of $147\frac{581}{1000}$ = ½ acre

A square of $104\frac{355}{1000}$ = ¼ acre

A lot 100 by 435.6 feet = 1 acre.

A circle 235.5 in diam. = 1 acre.

Adhesion.—The resistance to slipping due to the weight on drivers. In practice it is found necessary to make the weight on drivers about four times the tractive power. Some consider five times the tractive power to be safer.

Adiabatic Expansion.—Expansion taking place without heat transmission. In practice this never happens, and the isothermal expansion is much nearer correct.

Admission of Steam.—The opening of the port by the valve to admit steam is called the point of admission.

Air Brake.—A system of braking by air pressure now in universal use in this country and most others. The details of the system follow under this heading.

Air Brake Tests.—Galton.—Westinghouse tests 1878-79 on London, Brighton and South Coast Ry. One table is

Retarding Force in Proportion to Wt. of Train.	Length of Stop from 50 Miles per Hour—In Yards.
5	555⅝
10	277⅝
15	185
20	139
22	111
20	92⅝

Stopping distance seems to be nearly inversely proportional to percentage of braking power.

Air Brake Tests.—Paris and Lyons Railway Tests, 1879. Tests by M. George Marie, of Paris

Brake.	Speed of Train Miles per Hour. *	Length of Stop in Yards	Time for Stops in Seconds.
Weftinghouse.	37	217	20½
Vacuum.	35	280	24½

Absecon Tests.—On Atlantic City Division of West Jersey R. R., near Absecon, N. J., made to show stopping power of high speed as compared with ordinary quick action (Westinghouse). Former average over 25 per cent. better stops.

Atsion Tests.—1903 at Atsion, N. J., on Central R. R. of New Jersey, to compare Westinghouse and New York High Speed Brakes.

Burlington Brake Trials—1886-87. See Westinghouse book "Air Brake Tests"—too elaborate to make extracts.

Karner Tests.—Sept., 1902, at Karner, N. Y., on N. Y. C. and H. R. R. R. Two trains of 50 cars each of 60000 lb. cars; one New York and the other Westinghouse. See book above mentioned.

Nashville Locomotive Brake Tests.—Test on Nashville, Chattanooga & St. Louis Ry., at Nashville, 1895, to determine difference in length of stop whether engine is reversed with brake or brake only used. They favor dependence on brakes alone.

Sang Hollow Tests.—Made by Pennsylvania R. R. at West Penn Sang Hollow Extension, near Bolivia, Pa., to determine the advisability of operating Westinghouse and New

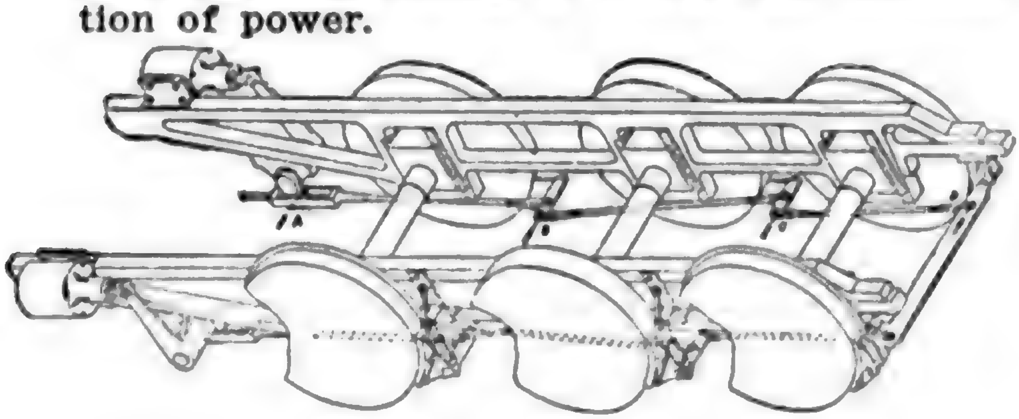
Thermal Test.—Testing heat of wheels at foot of grade. The warmest wheels have the best brakes, and if any are cold, these brakes are not doing full duty.

Westinghouse Freight Train Test.—1887.

Air Pump.—Pump operated by steam to compress air for braking and signal purposes. Made in various sizes by the New York and Westinghouse companies.

Air Pump—New York.—A duplex or compound air pump in which the air is compressed in two stages. There is a low pressure air cylinder which compresses free air and delivers to the high pressure cylinder which completes the compression. Both steam cylinders are the same. Steam used in a road test—876 pounds in 6,000 strokes.

American Driver Air Brake.—Plan as shown in diagram for equalizing pressure on all drivers instead of forcing between two, as with the cam brake. The illustration shows a perspective view of outside equalized pressure brake as applied to a six-wheel coupled engine, showing system of levers and distribution of power.



The power shown at bottom end of cylinder lever A is 30,000 pounds. This all goes to the lever at B, which is so divided that 10,000 pounds goes to the brake shoe, and 20,000 pounds to the lever at C. This lever is evenly divided, 10,000 pounds goes to the shoe there and 10,000 pounds to the brake beam connection at D, which equalizes the braking force on all shoes.

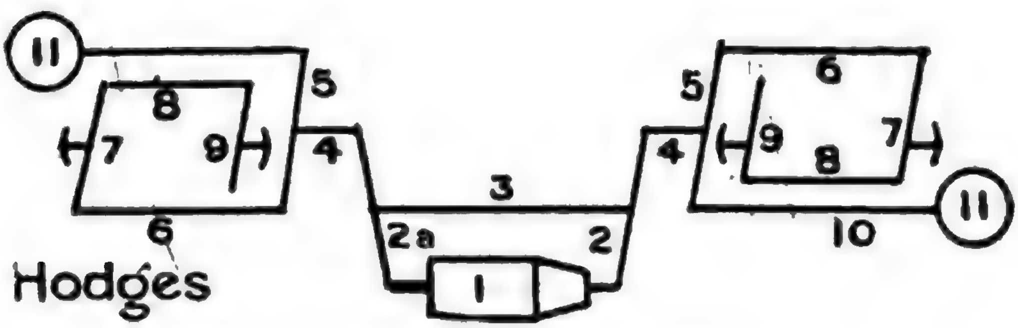
Automatic Brake.—The brake applies automatically whenever train pipe pressure is reduced, either by the engineer or train pulling in two. This operates all the brakes on the train.

Bleeding Brakes.—When brake fails to release owing to the failure of air to flow out of brake cylinder through triple valve, it is sometimes necessary to relieve the brake cylinder by opening "bleed" cock.

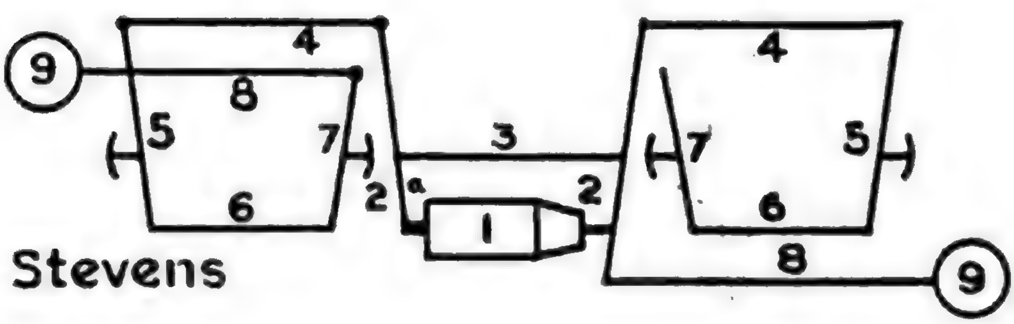
Brake Cylinder.—Cylinder containing piston against which air operates to force brake shoes against wheels. Varies in size according to size of car from 6 to 16 inches, as follows:

Kind of Cars.	Light Weight of Cars.	Size of Cylinders.
Passenger.	Exceeds 92,000	16 inch
Passenger.	68,000 to 92,000	14 "
Passenger.	47,000 to 68,000	12 "
Passenger.	30,000 to 47,000	10 "
Freight	Exceeds 40,000	10 "
Freight	15,000 to 40,000	8 "
Freight	Under 15,000	6 "
Tenders	Under 30,000	8 "
Tenders	30,000 to 47,000	10 "
Tenders	Exceeds 47,000	12 "

Brake Leverage.—Applies to whole system of levers between brake cylinder and brake shoes. Levers must be proportioned correctly or brakes will either act too strongly and slide wheels or too lightly and fail to stop train. Two main systems are Hodge and Stevens.



1—Brake cylinder, 2—Live cylinder lever, 2a—Dead cylinder lever, 3—Tie rod, 4—Hodge, 5—Hodge or floating lever, 6—Top rods, 7—Live truck lever, 8—Bottom rods, 9—Dead truck lever, 10—Hand brake connection, 11—Brake wheel.



1—Brake cylinder, 2—Live cylinder lever, 2a—Dead cylinder lever, 3—Tie rods, 4—Top rods, 5—Live truck lever, 6—Bottom rods, 7—Dead truck lever, 8—Hand brake connection, 9—Brake wheel.

Brake Power on Cars.—Passenger coaches — 90 per cent. of weight on wheels having brake shoes.

Freight cars—70 per cent. of light weight.

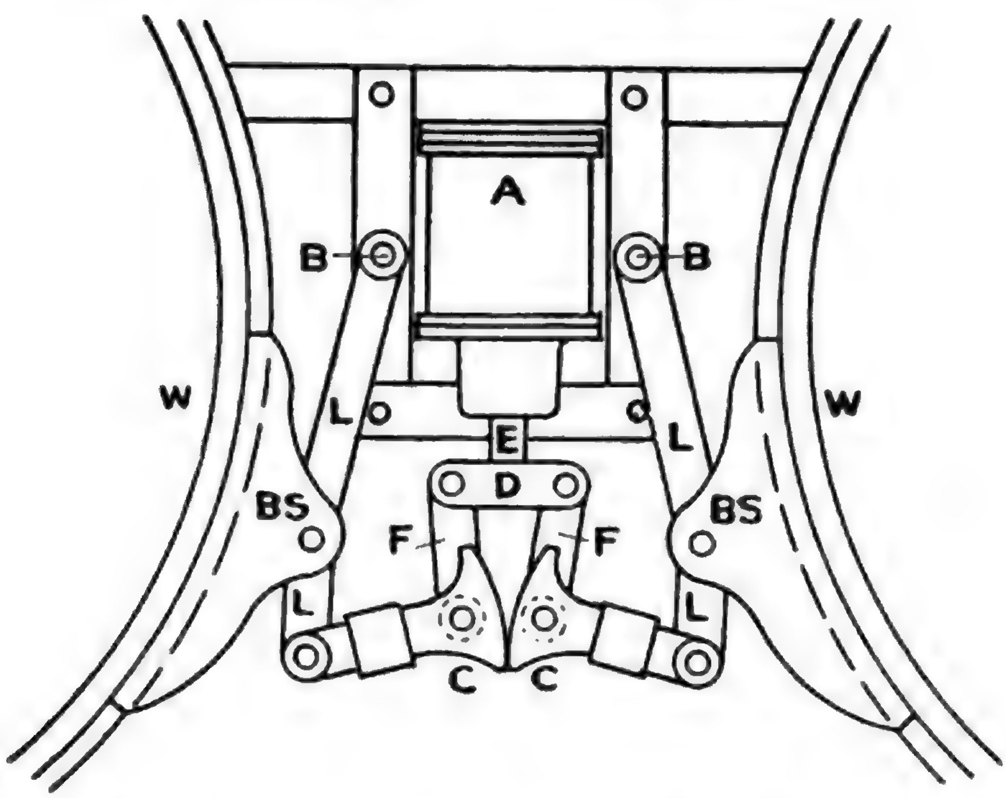
Tenders—100 per cent. of light weight.

Driver brakes—75 per cent, of weight on drivers.

Truck brakes—65 per cent. of weight on truck.

Brake Valve.—Valve in cab for engineer's use. Sometimes called engineer's valve.

Cam Brakes.—A form of driver brake not used on newer engines. The piston was forced down by air and cams rolling together, forced brake shoes against wheels.



A—Brake cylinder, B—Fulcrum of levers, C—Cams or cam shoes, D—Crosshead, E—Piston rod, F—Links, BS—Brake shoes, L—Levers, W—Wheels.

Car Discharge Valve.—Valve on each car having air train signals for discharging air to reduce pressure in whistle line and sound whistle in cab.

Cavity D.—See equalizing auxiliary.

Combined Automatic and Straight Air.—Combination to allow either to be used. This is only used on switch engines and in some freight service. It is good where very frequent brake applications are necessary or for slowing down to pick up a flag, etc. Each is independent of the other.

Compound Air Pump.—See Air Pump, New York.

Conductor's Valve.—Valve in car by which conductor or brakeman can reduce train line pressure and apply brake. Must be held open till the train comes to a full stop.

Cutting Out Brake on a Car.—Defective brakes are cut out of service by closing cock in the cross-over pipe.

Distributing Valve.—A new device of the Westinghouse Air Brake Co., which, combined with a small cast iron reservoir, does away with all engine and tender brake triple valves and auxiliary reservoirs. It simplifies equipment and reduces cost; increases flexibility and safety. Gives highest possible breaking effect at all times. Maintains equal pressure in all brake cylinders, regardless of number, size, variation of piston travel or leakage. The number of full re-applications that can be made immediately following release, is limited only by main reservoir and pump capacity. Allows locomotive brakes to be operated independently or with train brakes, at will.—Westinghouse Bulletin.

Emergency Application.—A quick and large reduction of train pipe pressure, so as to apply brakes as rapidly as possible. Only used in emergencies.

Emergency Position.—Brake valve with direct application port open so train pipe air can pass direct to atmosphere.

Equalizing Auxiliary.—Also called engineer's auxiliary and little drum. Sometimes called cavity D. Usually located under foot-board on either side. It furnishes volume of air on top of equalizing piston in engineer's valve.

Equalization.—The equalizing of pressure between auxiliary reservoir and brake cylinder or between main reservoir and train line.

Full Application.—Reducing train line pressure beyond the "service" point, say 20 pounds. This gives the usual brake application for a stop.

Full Release.—Brake valve position in which main reservoir pressure can pass into train pipe and release brakes.

High Speed Brake.—Latest development of the quick action automatic brake to enable the engineer to apply the brake ordinarily or to apply a higher braking force proportionate to speed of train. The friction of brake shoes is less at high speeds than low—so excess pressure is reduced as train slows down.

High Speed Brake.—Advantage of. Allows two full reductions of 20 pounds and releases without recharge of auxiliary reservoir while still leaving 70 pounds available for stop if necessary.

Holding Power of Brakes.—Depends on brake shoes, wheels and speed. Greater friction at low speed than high. Proportion of holding power to brake power applied is .074 at 60 miles an hour, .241 at 10 miles, .273 at 5 miles and .33 just as train stops. This is the reason for high speed brake carrying 110 pounds at first (making 125 per cent. of weight of coach and reducing to 60 pounds as speed reduces.)

Lap Position.—Brake valve so placed that no air can pass through or under the rotary.

Leakage Grooves.—Small grooves cut inside of brake cylinders at top or side. With brake piston in release position these are open so that a small passage of air will escape and not move piston. This prevents a small leak setting the brake. The first reduction of pressure must be heavy enough to move piston past this groove—5 to 7 pounds will do it.

Little Drum.—See Equalizing Auxiliary.

Loads Hauled on Grades.—See table under Grades.

Main Reservoir.—Reservoir on engine to supply pressure to train pipe to release brakes and recharge auxiliaries on tender and cars. This carries a higher pressure than the train line or auxiliaries. Usually 90 pounds, or 20 pounds higher than train line.

Piston Travel.—Refers to travel of brake cylinder piston. Usually adjusted to 8 inches, on standing test, as it travels about an inch farther when running. This is due to tilting of brake beams.

Piston Travel and Pressure.—

Train Pipe Reduction	Travel in Inch—Pressure Below							
	4	5	6	7	8	9	10	11
7	25	23	17½	13	10½	8	......	......
10	49	43	34	29	23½	19½	17	14
13	57	56	43	37½	33	29	24	30
16	....	....	54	47½	41½	36	29	24
19	....	....	....	61	47	40	36½	32
22	..	....	......	......	50	47½	44	39
25	....	...	.....	...	.....	.....	47	45

From Air Brakemen's Proceedings.

Pressure Retainer.—A valve which will hold some of the air in brake cylinders after triple has gone to release position. These have handles which are turned up to make them operative or down to cut them out. Their use makes it possible to recharge the auxiliary reservoirs and train pipe while running down a hill and still not entirely release brakes.

Pressure.—Standard. Train line and auxiliary, 70 pounds. Main reservoir, 90 pounds. Some roads are using a higher pressure, especially in mountain divisions.

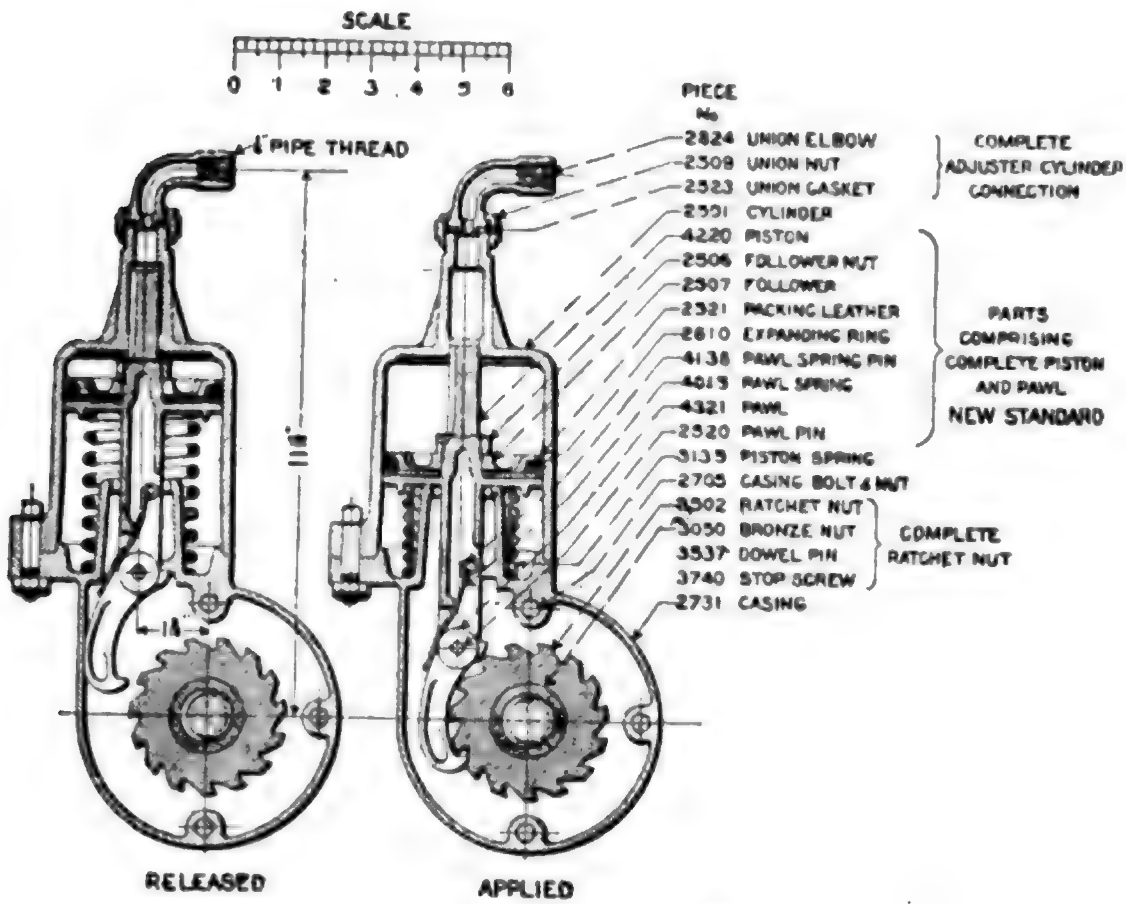
Reservoir.—Main, Capacity of.

22½ x 34 outside — about 11,200 cu. in.
24½ x 34 outside — about 14,000 cu. in.
26½ x 34 outside — about 15,800 cu. in.
20½ x 41 outside — about 12,200 cu. in.
22½ x 41 outside — about 14,000 cu. in.
24½ x 41 outside — about 17,400 cu. in.
26½ x 41 outside — about 20,000 cu. in.

Running Position.—Proper position of brake valve when train is running with brakes released.

Service Application.—Reducing the train line pressure slightly; 7 to 10 pounds, so as to secure a slight application of brake.

Slack Adjuster.—Automatic. A device for automatically taking up the slack in brake rigging so as to maintain an even travel of piston.



American Slack Adjuster.

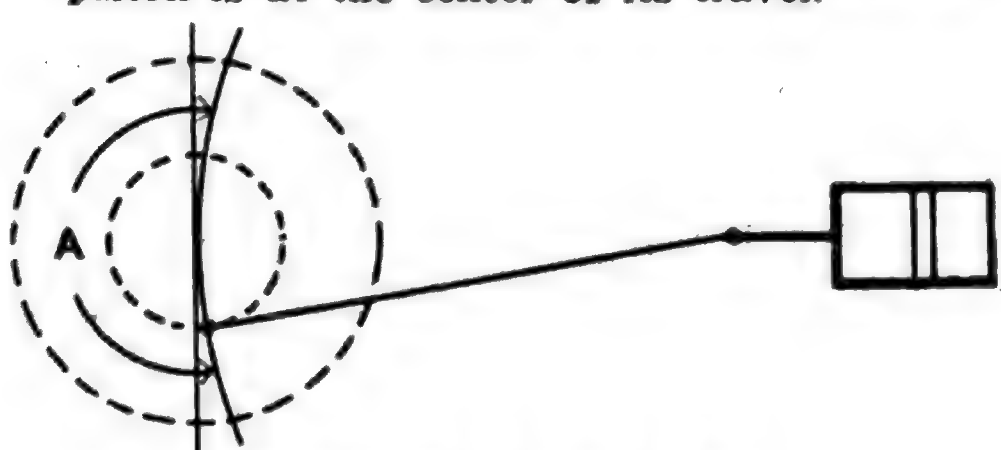
Air Signal.—Signal in cab for engineer. Operated by reduction of pressure in signal line. Air is supplied from main reservoir through reducing valve to give lower pressure. Reduction must be made suddenly.

Air Tools.—See Pneumatic Tools.

Albany Grease.—A compound for lubricating in place of oil.

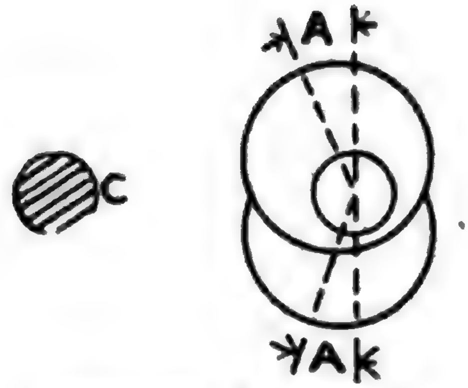
American Locomotive.—Designed by H. R. Campbell and built by Baldwin in 1836. Has a full truck and 4 coupled drivers, and is the best all round locomotive ever built. Also called "Eight wheelers."

Angularity of Rods.—The angle assumed by a rod having one end revolving and the other reciprocating, as the main rod shown. During the outer half of the piston stroke the crank pin travels more than half the revolution, as shown by A. In other words, the crank pin is not on the quarter when the piston is at the center of its travel.



Angularity of Main Rod.

Angular Advance.—Angle the eccentrics are advanced from the center line to give the desired lead. Eccentrics are shown advanced by the angle A toward the crank C.



Angular Advance.

Annealing.—Softening steel, rolled brass or copper by heating to a low heat and allowing to cool gradually. Allowing it to remain well covered with lime, sand or fuel while cooling.

Appropriation Plan.—A plan for allotting a certain amount of money each month or year for running expenses of shop, roundhouse, etc. The object is to induce economy, to give the managers a knowledge of the money required, etc. Some claim excellent results from it, others have serious objections.

Area.—The number of square inches (or feet, or yards, as the case may be), in a surface of any kind. Applied to a pipe or cylinder it means the area of one end, and not the contents of the whole length. In a circle the area varies as the square of the diameter. In a square as the square of the side. This means that a circle four inches in diameter is four times as large (in area) as one two inches in diameter, or a two-inch square is one-fourth as large as a four-inch square.

Area of Pistons.—Amount of space (in square inches) on a piston head or cylinder head. Offers a good means of comparing locomotives. Rule is—multiply diameter by itself

(called squaring it), and this result by .7854. Cylinder, 20 inches. 20×20=400. This multiplied by the decimal .7854, area in square inches, gives 31.416.

Area of Port—Exhaust.—Usually about double that of steam port.

Area of Port—Steam.—About 9 per cent. of cylinder area. Varies from 7 to 10 per cent.

Armored Hose.—Hose with a woven metal protection covering on outside. Section hose or vacuum brake hose has a spiral coil of wire inside to prevent collapsing.

Ash Pan.—Pan under fire box to prevent live coals and ashes dropping on ties, and to enable air to be shut out from under grates. Made of sheet or tank iron, of various shapes to fit different locomotives, and provided with dampers or doors to regulate air and dump ashes when desired.

Atlantic Locomotive.—Has a full truck, 4 coupled drivers and a pair of trailers. Usually coupled to second pair of drivers.

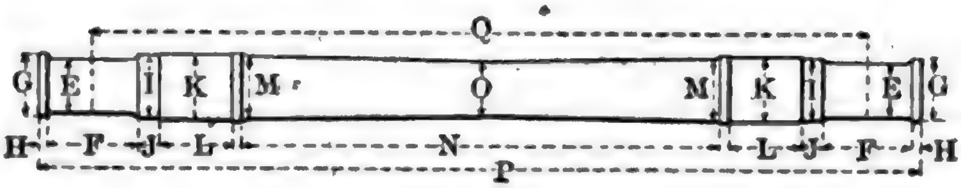
Axle Bearing.—See journal bearing.

Axle Box.—See journal box.

Axles—Drop test. See Drop test.

Axle—Pressure On.—This varies with different roads and service. Rarely exceeds 26,000 pounds on a wheel, and is usually carried on bearings with a pressure not exceeding 250 to 300 pounds per square inch of projected area. Projected area is diameter of bearing multiplied by its length. Thus an 8x12 bearing would have 96 square inches projected area.

PRINCIPAL DIMENSIONS OF M. C. B. AND P. R. R. STANDARD AXLES.



NOTATION.	MARK.	Size of Journal. Diameter.	Size of Journal. Length.	Diameter of Collar.	Length of Collar.	Diameter of Dust Guard Seat.	Length of Dust Guard Seat.	Diameter of Wheel Seat.	Length of Wheel Seat.	Diameter at End of Taper.	Distance between Shoulders.	Diameter at Center.	Length over All.	Center to Center of Journals.	Average Maximum Weight.
		DIMENSIONS IN INCHES.													Pounds.
		E	F	G	H	I	J	K	L	M	N	O	P	Q	
M. C. B.	A	3 3/4 x	7	4 3/4	5/8	4 3/4	2 1/2	4 7/8	7 1/4	4 5/8	46	4 1/4	83 1/4	75	400
Axles	B	4 1/4 x	8	5 1/4	5/8	5 1/4	2	5 3/8	7 1/4	5 1/2	48 1/2	4 3/8	84 1/4	75	505
Standard	C	5 x	9	6 1/4	3/4	6 1/4	2	6 3/8	7 1/4	6 1/8	47	5 3/8	86 1/2	76	680
of 1900.	D	5 1/2 x	10	6 5/8	3/4	6 5/8	2	6 7/8	7 1/4	6 11/16	46	5 7/8	88 1/2	77	815
M. C. B.	A	3 3/4 x	7	4 3/4	5/8	4 3/4	2 1/2	5 1/8	7 1/4	5 1/8	47	4 1/4	83 1/4	75	425
Axles	B	4 1/4 x	8	5 1/4	5/8	5 1/4	2	5 3/4	7 1/4	5 3/4	47	4 3/4	84 1/4	75	535
Standard	C	5 x	9	6 1/4	3/4	6 1/4	2	6 1/2	7 1/4	6 1/4	47	5 1/8	86 1/2	76	700
of 1901.	D	5 1/2 x	10	6 5/8	3/4	6 5/8	2	7	7 1/4	7	46	5 5/8	88 1/2	77	830
M. C. B.	A	3 3/4 x	7	4 3/4	5/8	4 3/4	2 1/2	5 1/8	7 1/4	4 7/8	46	4 1/4	83 1/4	75	410
Axles	B	4 1/4 x	8	5 1/4	5/8	5 1/4	2	5 3/4	7 1/4	5 7/16	46	4 3/4	84 1/4	75	520
Standard	C	5 x	9	6 1/4	3/4	6 1/4	2	6 1/2	7 1/4	6 3/16	46	5 3/8	86 1/2	76	685
of 1902.	D	5 1/2 x	10	6 5/8	3/4	6 5/8	2	7	7 1/4	6 3/4	46	5 7/8	88 1/2	77	820
P. R. R.	2B	3 3/4 x	7	4 5/8	5/8	4 5/8	2 3/8	5 3/8	7 1/4	5 1/8	46	4 7/16	83	74 3/4	440
	4B	4 1/4 x	8	5 1/4	5/8	5 1/4	2	5 3/4	7 1/4	5 1/2	46	4 3/4	84 1/4	75	519
Standard	4A	4 1/4 x	8	5 1/2	5/8	5 1/2	2 7/8	5 3/4	7 1/4	5 1/2	46	4 3/4	86	76 3/4	535
	6A	5 x	9	6 1/4	3/4	6 1/4	2	6 1/2	7 1/4	6 1/8	46	5 3/8	86 1/2	76	680
Axles.	7	5 1/2 x	10	6 5/8	3/4	6 5/8	2	7	7 1/4	6 11/16	46	5 7/8	88 1/2	77	820

NOTE.—Tables show finished sizes. Rough-turned sizes are about 1/8" larger. Weights stated are for axles rough-turned on journals and wheel seats.

Axles.—Rough-turned. Axles furnished after being turned roughly to remove superfluous metal and take away the roughness of forging.

Axles—Smooth Forged. Axles forged smoothly enough so as not to require turning; claimed to be better, as the tough outer skin of metal is not removed as in rough turning.

Axle Light.—Name given to the system of lighting cars electrically by dynamos driven from axle of cars. A storage battery is used to furnish current for lamps when car is standing or when speed is too low to generate the required voltage for lamps.

B

Baldwin Balanced.—An engine of the De Glehn type. High pressure cylinders inside frame, low pressure outside. One piston valve controls both.

Bissell Truck.—Named from designer. Any truck which swings from a point behind the center (in a leading truck) instead of turning on a center pin. Mr. Bissell first patented a four-wheel truck in 1857 and a "pony" truck in 1858.

Blades.—Same as eccentric rods. See eccentric rods.

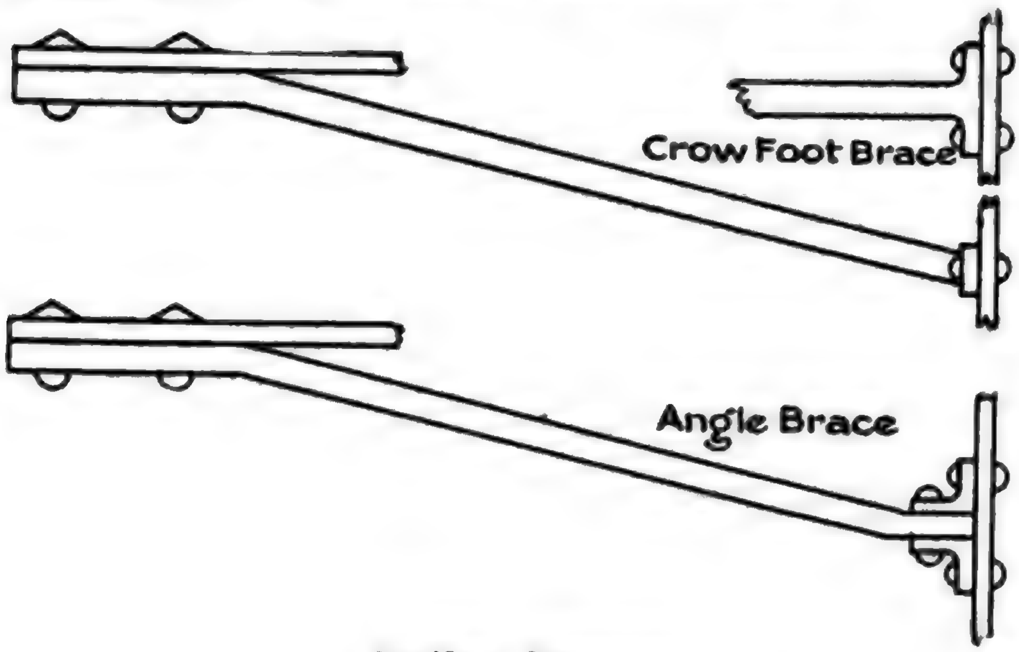
Body Bolster.—Sometimes called body transom—see bolster.

Bogie.—English name for 4 or 6 wheel truck contained in a frame by themselves and independent of engine or car except at center bearing.

Boiler—Back Head.—The outside sheet at back of boiler containing fire door.

Boiler—Belpaire.—Both the crown sheet and boiler sheet above it are flat. Designed to give more steam room and to present flat surfaces for staying. The comparatively square corners give more or less trouble from leakage due to unequal expansion.

Boiler Braces.—Bracing heads to shell.



Boiler Braces.

Boiler—Crown Sheet.—The top or upper sheet of the firebox.

Boiler Flange.—See Flange-boiler.

Boiler—Flue Sheet.—Generally applied to sheet next to firebox for holding back ends of flues. Front flue sheet is usually called "front sheet."

Boiler—Front Sheet.—Front sheet for holding flues in boiler.

Boiler—Mud Ring.—Iron frame—ususally square forged—which connects inner and outer sheets of the bottom of firebox. Also called foundation ring.

Boiler Pressure.—Steam pressure as registered by the steam gauge. See pressure gauge.

Boiler—Side Sheet.—Sheet forming side of firebox, connecting with crown sheet and riveted to mud ring. The large sheets now used combine crown and side sheets.

Boiler—Slope Sheet.—The sheet connecting the smaller and larger diameter of a wagon top boiler.

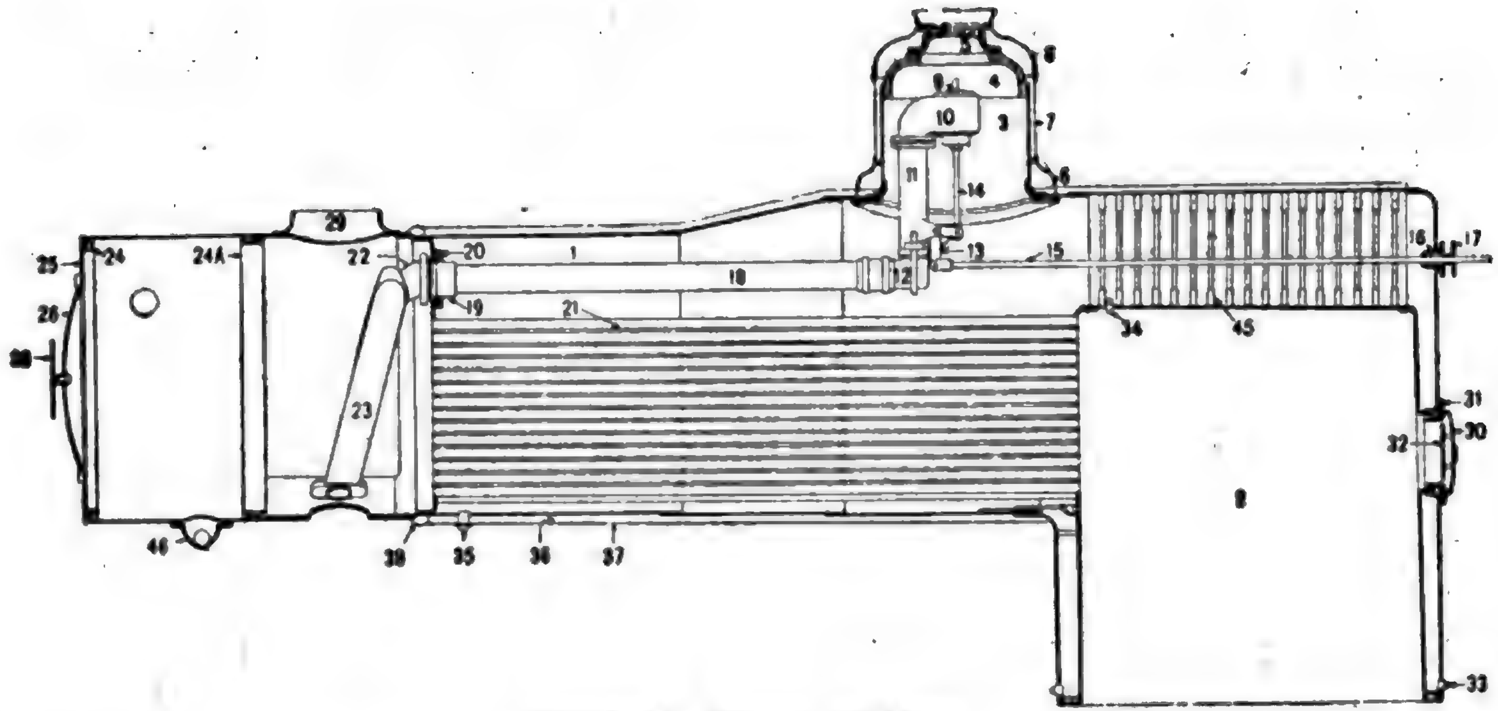
Boiler Tester.—Instrument for putting pressure on boiler to test it. Made like an injector with special tubes for getting high pressure. The best known is the Rue, which combines an injector for filling boiler quickly and an injector for testing it.

Boiler—Throat Sheet.—Sheet connecting the cylinder part of boiler with the firebox.

Boiler.—Mallet compound on B. & O. Weighs 84,000 lbs. empty. Tubes weigh 27,000 lbs. H. S. 5591 sq. ft.; grate 72.25 sq. ft.; length 38′ 5″.

Boiler.—Vanderbilt. Locomotive boiler designed by Cornelius Vanderbilt, with a round corrugated firetube of large diameter, similar to marine practice. No staybolts, but sling stays at front to support shell. Two connections underneath for removal of ashes. First one built for New York Central in 1900. Similar in many ways to Lenz (German) boiler.

Boiler—Wagon Top.—Designed in the days of smaller diameter boilers to afford additional steam room. Has been largely used, but seems to be giving way to the straight boiler of large diameter.

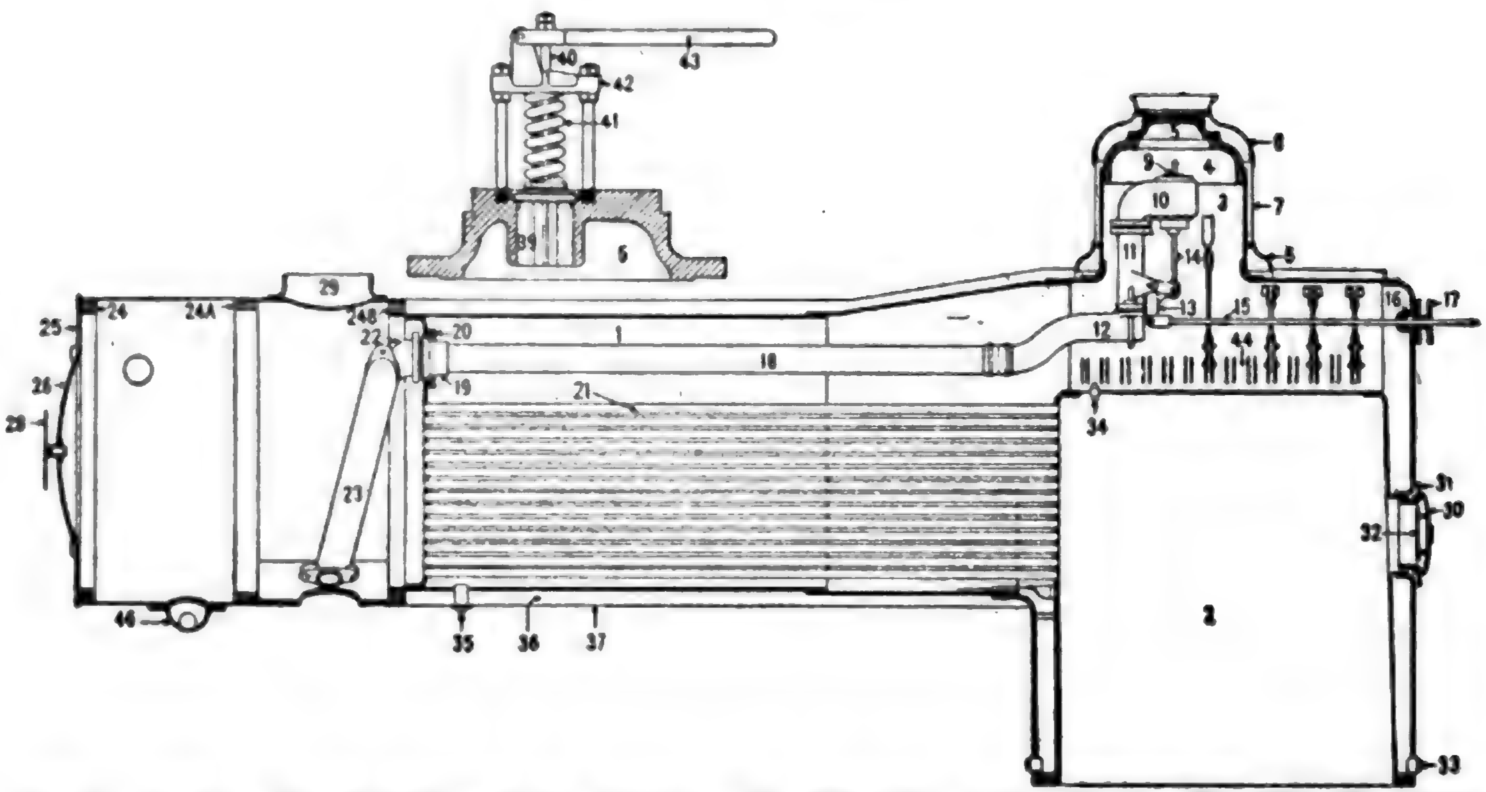


Radical Stay Boiler.

Boiler Parts.—

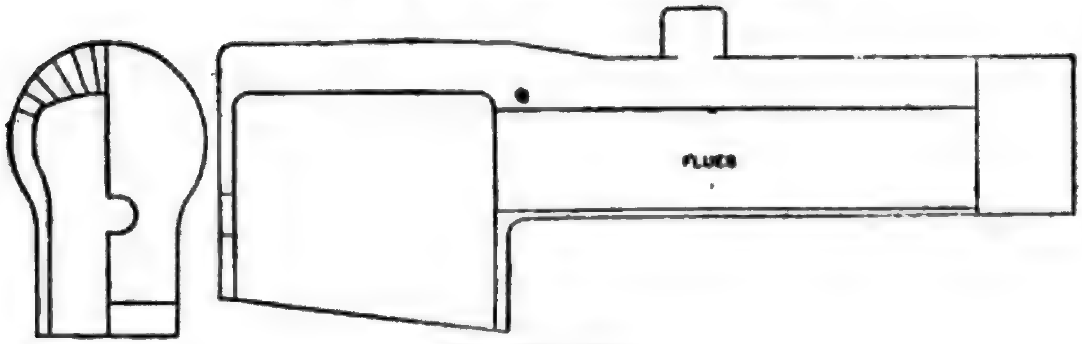
1, Boiler. 2, Firebox. 3, Dome. 4, Dome ring. 5, Dome cap. 6, Dome base. 7, Dome casing. 8, Dome cover. 9, Throttle valve. 10, Throttle valve box. 11, Throttle pipe. 12, Throttle pipe elbow. 13, Throttle valve crank. 14, Throttle valve rod. 15, Throttle valve stem. 16, Throttle stuffing box. 17, Throttle stuffing box gland. 18, Dry pipe. 19, Dry pipe front end. 20, Dry pipe ring on tube sheet. 21, Tubes. 22, Double cone. 23, Steam pipes, right and left. 24, Smoke box ring. 24a, Smoke box middle ring. 24b, Smoke box

CROWN BAR TYPE.

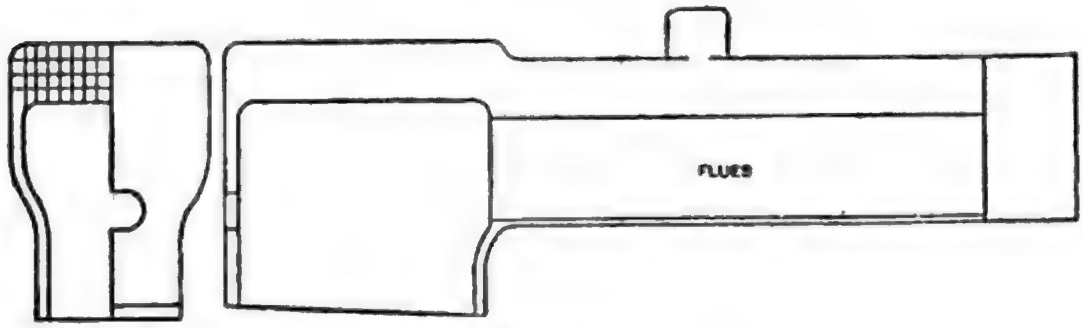


back ring. 25, Smoke box front. 26, Smoke box door. 27, Smoke box door liner. 28, Number plate. 29, Smoke stack base. 30, Fire door. 31, Fire door frame. 32, Fire door liner. 33, Corner plug. 34, Fusible plug. 35, Waist plug. 36, Lagging. 37, Jacket. 38, Smoke box band. 39, Safety valve. 40, Safety valve stem. 41, Safety valve spring. 42, Safety valve spring cap. 43, Relief lever. 44, Crown bar. 45, Staybolt. 46, Spark ejector.

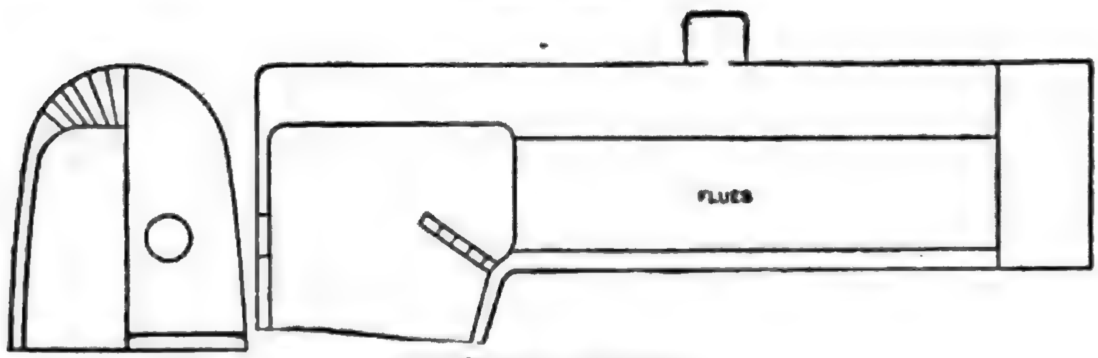
TYPES OF LOCOMOTIVE BOILERS.



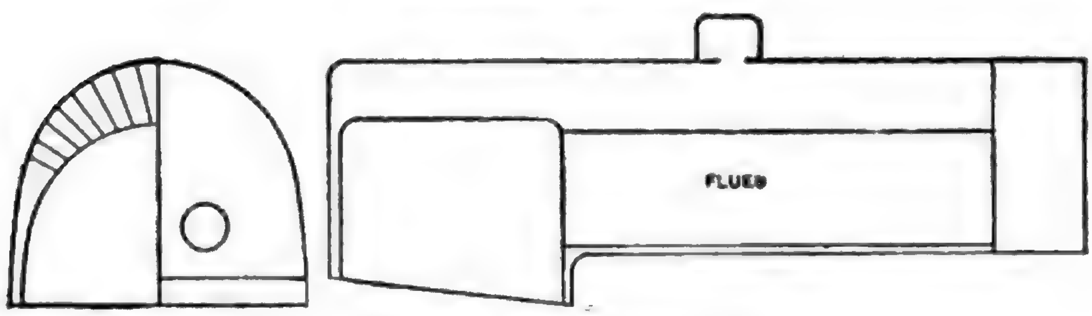
WAGON TOP



BELPAIRE.

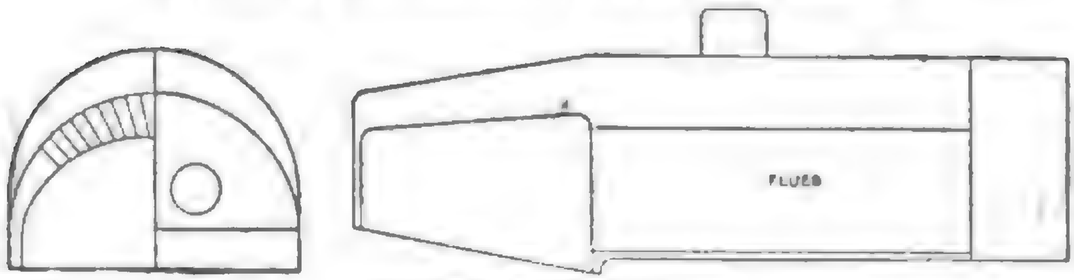


EXTENDED FIREBOX.

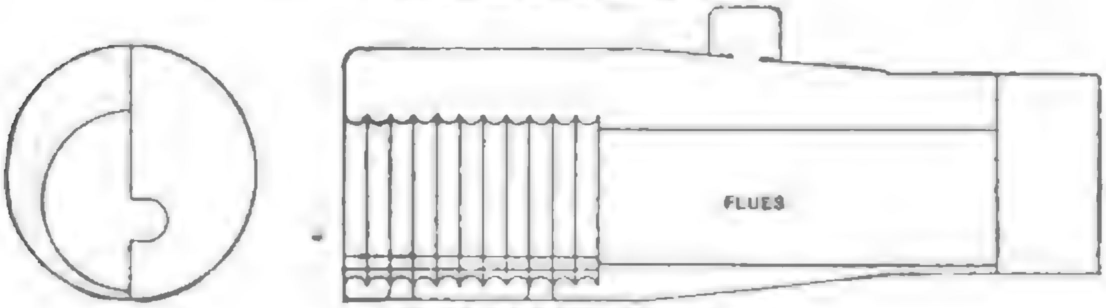


WOOTEN WIDE FIREBOX.

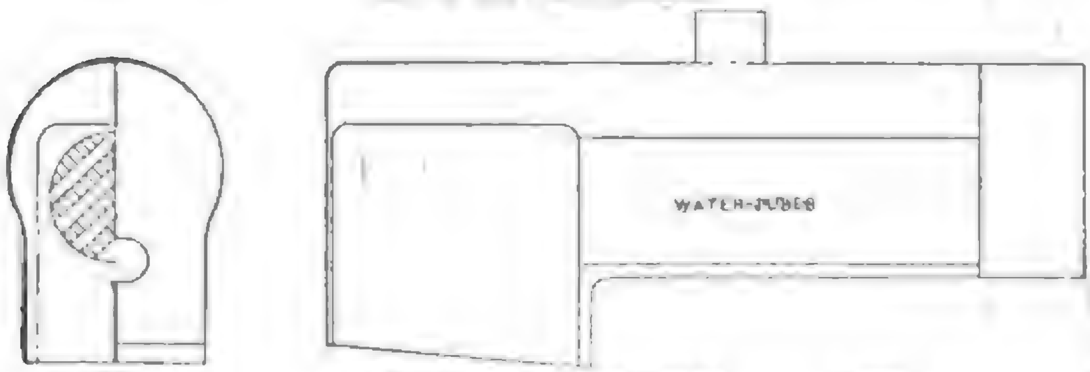
TYPES OF LOCOMOTIVE BOILERS—Continued.



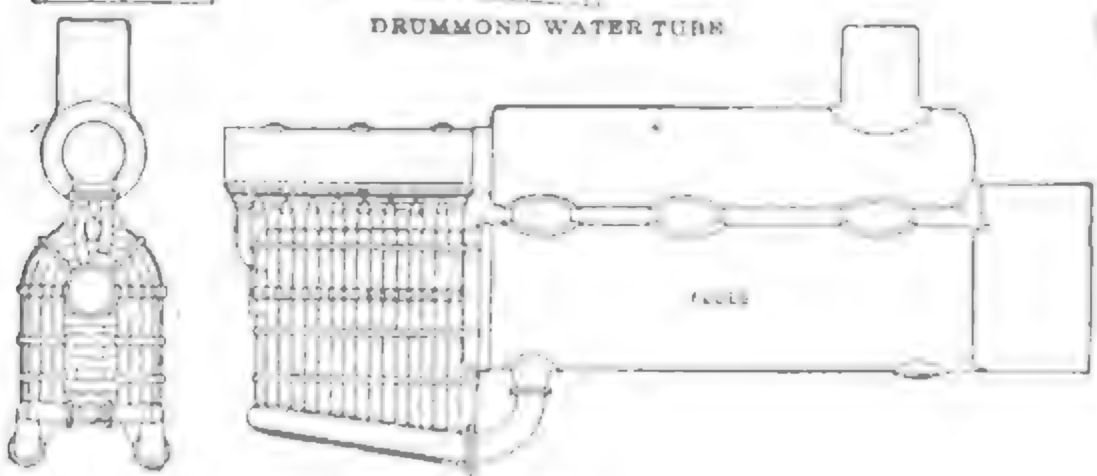
WOOTEN LOW CROWN.



LENTZ OR VANDERBILT.

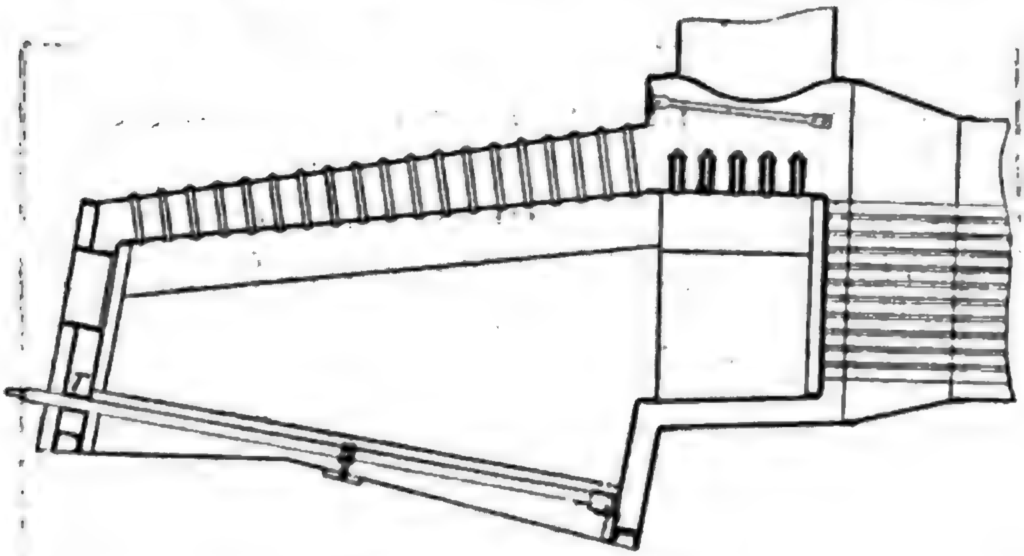


DRUMMOND WATER TUBE



BROTAN.

Boiler—Milholland.—Sometimes called swallow-tail. Made to reduce overhanging weight behind drivers.



Millholland Boiler—1851.

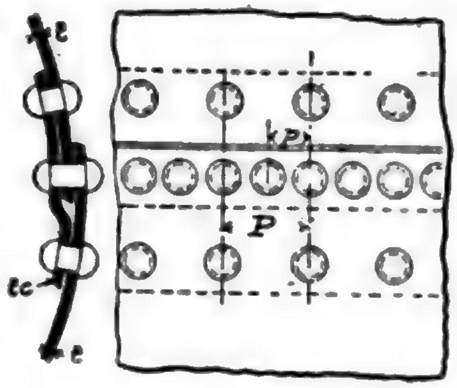
Boiler Washer.—A device which uses the injector principle for washing out boilers with hot water and filling them for testing. Test is applied by a special injector, which can maintain a pressure of three to five times of the boiler supplying steam.

Boiler.—Wooten. The name given by many to all boilers with firebox extending over driving wheels. The claim of the inventor was a wide firebox extending over wheels, a brick arch and a combustion chamber. The claims would not hold as indicated by the withdrawal of suit against alleged infringers. Credit for wide firebox belongs to Zerah Colburn, 1857.

Bolster.—Cross-piece under car which supports car body on truck. One on car is "body" bolster—other is truck bolster.

Bottom Center Plate.—See center plate. Sometimes called "female" center plate.

Single-Riveted Lap-Joint with Inside Cover-Plate.



(1) Resistance to tearing between outer row of rivets $= (P-d)tT$

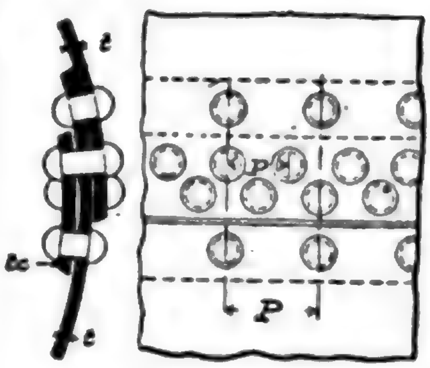
(2) Resistance to tearing between inner row of rivets, and shearing outer row of rivets $(P-2d)tT+\frac{\pi d^2}{4}S$

(3) Resistance to shearing three rivets $\frac{3\pi d^2}{4}S$

(4) Resistance to crushing in front of three rivets $= 3tdC$

(5) Resistance to tearing at inner row of rivets, and crushing in front of one rivet in outer row $= (P-2d)T+tdC$

Double-Riveted Lap-Joint with Inside Cover-Plate



(1) Resistance to tearing at outer row of rivets $= (P-d)tT$

(2) Resistance to shearing four rivets $= \frac{4\pi d^2}{4}S$

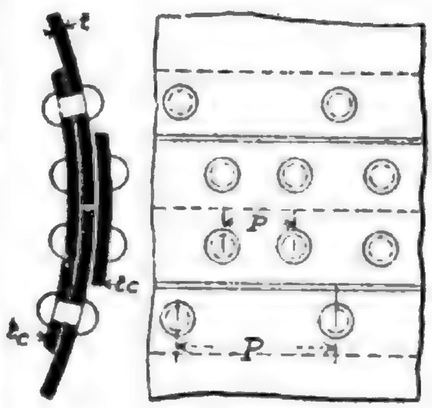
(3) Resistance to tearing at inner row and shearing outer row of rivets $(P-1\frac{1}{2}d)tT+\frac{\pi d^2}{4}S$

(4) Resistance to crushing in front of four rivets $= 4tdC$

(5) Resistance to tearing at inner row of rivets, and crushing in front of one rivet $= (P-1\frac{1}{2}d)tT+tdC$

Boiler Seams.

Double-Riveted Butt-Joint



(1) Resistance to tearing at outer row of rivets $= (P-d)\,t\,T$

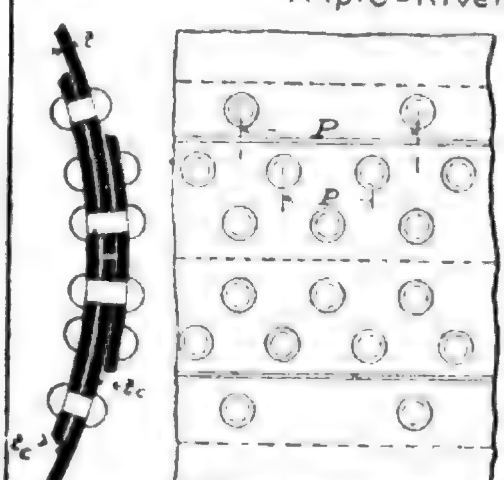
(2) Resistance to shearing two rivets in double shear and one in single shear $= \frac{5\pi d^2}{4} S$

(3) Resistance to tearing at inner row of rivets and shearing one of the outer row of rivets $= (P-2d)\,t\,T + \frac{\pi d^2}{4} S$

(4) Resistance to crushing in front of three rivets $= 3\,t\,d\,C$

(5) Crushing in front of two rivets and shearing one rivet $= 2\,t\,d\,C + \frac{\pi d^2}{4} S$

Triple-Riveted Butt-Joint



(1) Resistance to tearing at outer row of rivets $= (P-d)\,t\,F$

(2) Resistance to shearing four rivets in double shear and one in single shear $= \frac{9\pi d^2}{4} S$

(3) Resistance to tearing at middle row of rivets and shearing one rivet $= (P-2d)\,t\,F + \frac{\pi d^2}{4} S$

(4) Resistance to crushing in front of four rivets and shearing one rivet $= 4\,d\,t\,C + \frac{\pi d^2}{4} S$

(5) Resistance to crushing in front of five rivets $4\,d\,t\,C + d\,t_c\,C$

Boiler Seams.

Failure of Riveted Joints

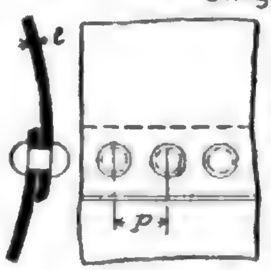
A riveted joint may fail by shearing the rivets, tearing the plate between the rivets, crushing the rivets or plate, or by a combination of two or more of the above causes.

To determine the efficiency of a riveted joint, calculate the breaking strength by the different ways in which it may fail. That method of failure giving the least result will show the actual strength of the joint. If this equals S_R, and S = tensile strength of the solid plate, then efficiency $= \frac{S_R}{S}$

Nomenclature

d = *diameter of rivets.*	P = *pitch of outer row of rivets*
t = *thickness of plate*	S = *shearing strength of rivets*
t_c = *thickness of cover plates*	T = *tensile strength of plate*
p = *pitch of inner row of rivets*	C = *crushing strength of rivets.*

Single-Riveted Lap-Joint

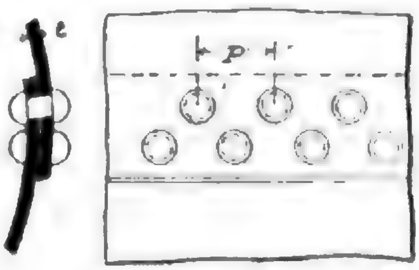


(1) *Resistance to shearing one rivet* $= \frac{\pi d^2}{4} S$

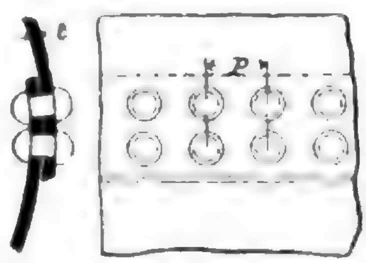
(2) " " *tearing plate between rivets* $= (p-d)\,t\,T$

(3) " " *crushing of rivet or plate* $= d\,t\,C$

Double Riveted Lap-Joint



Staggered Riveting



Chain Riveting

(1) *Resistance to shearing two rivets* $= \frac{2\pi d^2}{4} S$

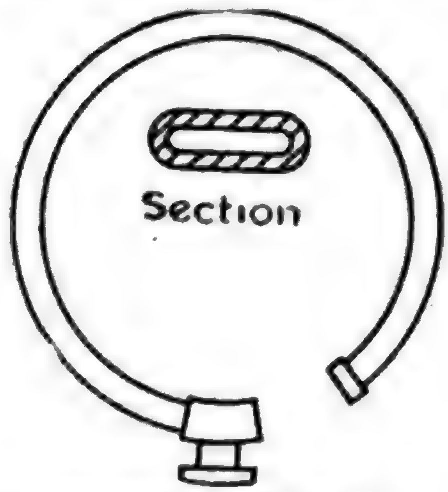
(2) " " *tearing between two rivets* $= (p-d)\,t\,T$

(3) " " *crushing in front of two rivets* $= 2d\,t\,C$

Boiler Seams.

Bourdon Spring.—A flattened tube fastened at one end or in the center, and used in steam and other gages. Pressure on inside tends to make tube round and moves the face end or ends. Named from inventor.

Boyles Law.—See Mariottes Law.



Bourdon Spring.

Brake Beams.—Steel or wood. Tests made in 1904 proved that the trussed wooden beam stood the M. C. B. test better than any metal beam. M. C. B. tests require all beams to withstand a load of 750 lbs. at the center without more than 1-16 inch deflection.

Brake Beams.—M. C. B. standard length is 60½ inches from centers of brake heads. M. C. B. standard height is 14½ inches from top of rail to center of brake shoes for outside hung and 13 inches for inside hung on 33-inch wheels. Center line of brake hangers should be 90 degrees from a line drawn through center of brake shoe and center of wheel when shoe is half worn out. M. C. B. test for brake beam is a capacity of 750 pounds. This is too light for heavy freight cars, and 1,500 pounds is recommended.

Fig. 1

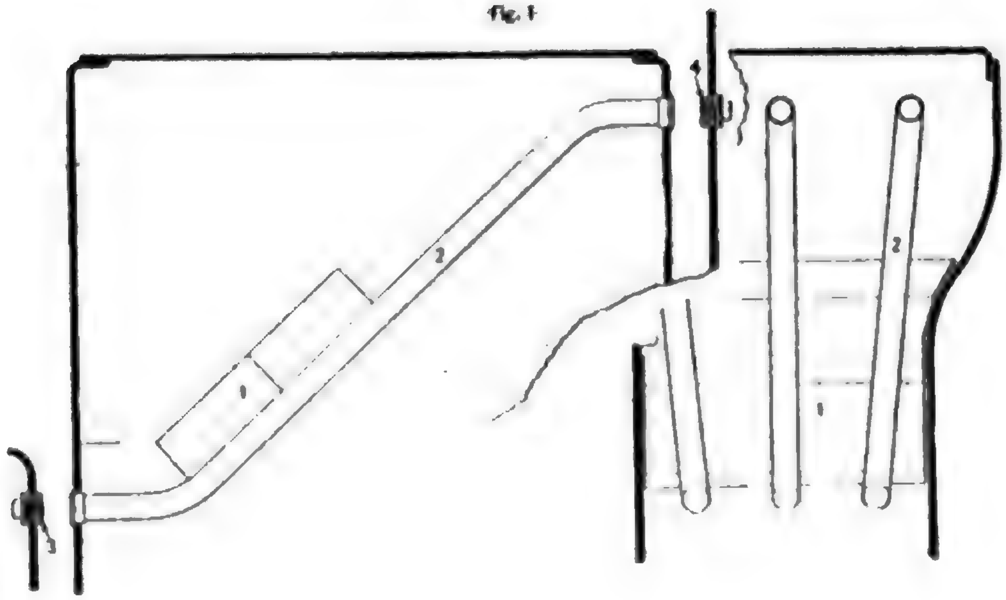
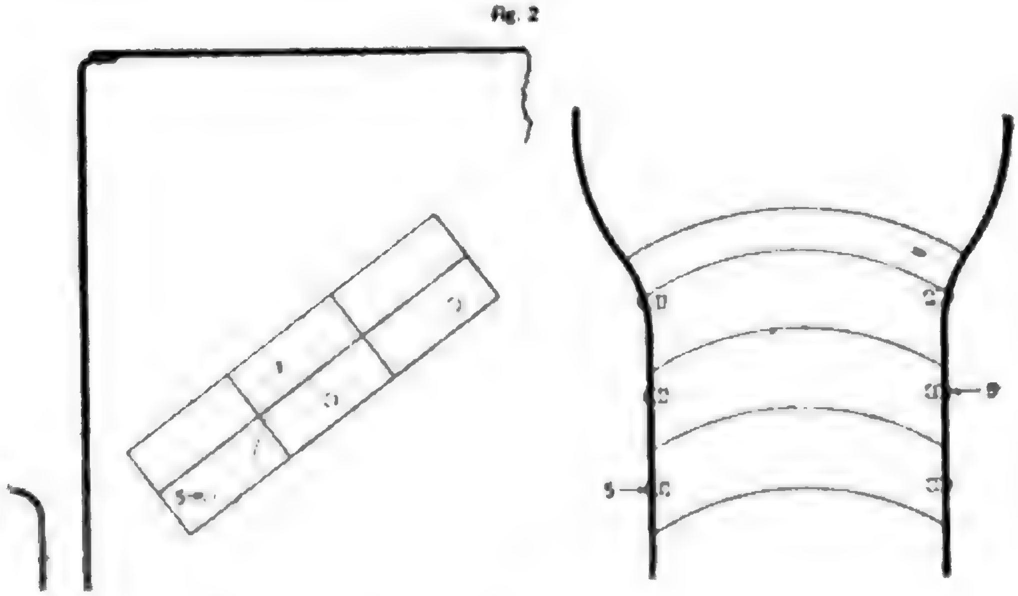


Fig. 2



Brick Arches.—1. Fire brick. 2. Fire brick tube. 3. Fire brick tube front plug. 4. Fire brick tube back plug. 5. Fire brick stud.

Brakes.—Historical.

1833—Stephenson patented his steam brake.

1844—Jas. Nasmyth and Chas. May patented a vacuum brake.

1848—Samuel C. Lister patented air brake with axle driven pump, reservoirs, etc; virtually a "straight air" brake operated by the guard in place of the engineer.

1853—First American brake patent. Large spiral spring which was wound up by brakeman after leaving station; released by engineer to apply brakes.

1855—Loughridge Chain Brake. Drumon engine was forced in contact with driving wheel by engineer and practically "wound up" the brakes on the train by means of chains.

1869—Westinghouse non-automatic or "straight air".

1872—Plain automatic, Westinghouse.

1872—Smith "vacuum" brake.

Brake Shoe Friction.—See Air Brakes, Friction of Shoes.

Brake Staff.—Staff or shaft between hand wheel and brake chain. Sometimes called brake shaft.

Briquetts or fuel bricks are used quite extensively in Germany where they vary from 3 to 10 pounds. They are oblong in shape and burn slowly if left whole, but rapidly if broken up small. State railroads of Prussia used 75,000 tons a month in 1902.

Briquettes were proposed as early as 1594 by Sir Hugh Holt and used in France in 1843. (W. H. Booth.)

American briquettes have about 5 per cent. of pitch and 2 per cent. of lime, the latter absorbing the sulphur that may be present.

Heating value of coal per pound is a variable quantity, depending not only on the kind of coal but the ash it contains. The average total heating value of the combustible portion is given approximately as follows: B. T. U. standing for British Thermal Units or the heat required to raise 1 pound of water from 39.2° to 40.2°.

Bristol Roller Valve.—See Valves.

British Thermal Unit.—Same as heat unit.

Buffer Block.—See Dead Wood.

Bull Nose.—See Drawbar.

Bunter Block.—See Deadwood.

Bunsen Burner.—A burner which draws in air around the gas outlet as shown. It makes a blue flame with very little light but intense heat. Largely used in shops for soldering and brazing.

By-Pass.—Pipes or passages for allowing steam or water to pass around the piston or pump. In the Vauclain compound it allows the steam to pass to both sides of high pressure piston so as to get line steam to low pressure piston. On some compounds they are used in drifting to prevent turning low pressure into an air pump.

C

Cabin.—See Cupola.

Calorie.—French thermal unit. The quantity of heat required to one kilogramme of pure water one degree centigrade at about 4 degrees centigrade, which is equivalent to 39.1 degrees Fahr. One calorie=3.968 British thermal units and 1 B. T. U.=.252 calorie.

Camel Back.—Name given to a class of locomotives brought out by Ross Winans in 1848 on account of cab being over center of boiler. Is also applied to any locomotive with its cab in this position.

Cams.—In locomotive practice, a name sometimes given to eccentrics.

Carborundum.—An abrasive material made from mineral or earth products by being treated electrically to extremely high temperature. Next to diamond in hardiness. Strange to say, it can also be so treated as to closely resemble graphite and become a good lubricant.

Card.—See Indicator Card.

Car Heating—Baker System. The Baker Heater System consists in the main of a stove, supplied with a coil of pipe within the fire pot, an expansion tank or drum on the roof above the stove and connecting with the upper end of the coil, and a system of pipes, all connecting in a series of bent or straight radiators under the seats or along the truss planks of the car. This series of pipes extends in an unbroken circuit from the expansion drum down to the floor and along the side of the car on which the heater is located, thence across the car and in a similar way along the other side, then back again to the first side and along that one or more times to the inlet of the stove coil, and through the stove coil and pipes above to the expansion drum again. The circuit of pipes is filled with water, salt or fresh, up to the overflow of the expansion drum, which is then closed tightly.

Car Heating.—Standard System. In the "Standard System" the aim is to replace the heat of the fire with the heat of steam (the supply of the latter being drawn from the locomotive), leaving the Baker Heater System in such condition that a fire can be started at any time if needed. To accomplish this, steam jackets are used, one located near the heater, on the pipe leading to the bottom of the coil, and the others on the pipes leading to and from the radiating pipes on the side of the car opposite the heater side, and known as the "crossovers" (or connected into the circulation near the middle of the car, in the case of a double circulation car.) Steam from the engine is conducted from car to car by means of

suitable flexible couplings and pipes beneath the floor, the pipes being designated as "train pipes." These train-pipes are so arranged as to admit of gravity drainage from a selected high point to each end of the car. At this high point a fitting is placed, permitting a portion of steam to be withdrawn for the use of the car.

Car Heating.—Standard with Return Train Pipes. The fundamental principle of this system lies in the use of live or exhaust steam from the locomotive to replace the heat of the fire in a Baker Heater system, the condensation of the steam being returned to the locomotive after use, instead of being discharged to the ground. The heating jackets used in this system are double, and are placed so as to divide each circulation of a double circulation into an equal number of parts.

The locomotive is equipped with a powerful vacuum pump on the tender, and the cars with two train-pipes instead of the usual one. These train-pipes are supplied with flexible couplings from car to car, and are arranged to drain from the train-pipe cocks toward the end of each car.

The train-pipe cocks are a type of 3-way cock by which steam can be passed along to the following car, while still admitting a portion of the supply to its own car, or can be so turned as to prevent the passage of steam beyond itself if it is the rear one of the train. Either train-pipe will serve as the delivery train-pipe, according to location of the engine, the other then becoming the return train-pipe. The train-pipe on the left hand side when facing toward the en-

gine is the delivery pipe. Steam entering through the train-pipe cock in the delivery train-pipe is conducted to a 4-way cock by which it is directed towards the heater room of the car.

In case the vacuum pump is disabled or other defect develops, or that the engine attached is not equipped with a pump, the system may be used "discharging." In this case the supply of the steam is made as usual through the left hand train-pipe and the 4-way valve, but after passing through the jackets the condensation is discharged to the track, in full or reduced quantity as desired, through the drain cock.

Cars—English. Maximum total width of passenger cars is 9 ft. 3 in.

Car—Flat—Steel underframe 100,000 lbs. Total length, 40 ft.; center to center of trucks 30 ft.; width, 9 ft. 5 in.; weight, 37,840 lbs.; top of rail to floor, 4 ft. 2½ in.

Cars.—Passenger. Average, 72 feet over sills; weighs 52 to 55 tons; seats 86 passengers; six wheel truck; journals, 5 × 9 inches; steel platforms; wide vestibule, etc. Costs $10,000.

Cars.—Passenger. Great Northern Ry. 1904.—Barney & Smith Builders. Length, 80 feet; weight, 111,250 lbs.; width, 10 ft.; total wheel base, 66:10 1-2; 6 wheel trucks with 11 ft. wheel base. 86 passengers.

Car Repairs.—Average of 38,140 passenger cars for renewal and repairs, $744 per car. Average of 1,715,249 freight cars for renewals and repairs, $62 per car. Another large road gave average of $578 per passenger car, and $43 per freight car. Average cost of repairs on wooden cars, $79.65; same for steel cars, $25.67.

Car Repairs.—The allowances of the Master Car Builders' Association are as follows: Cars in service, June 30. 1903 (Interstate Commerce report), in U. S.: Passenger, 38,140; Freight, 1,653,782; Companies service, 61,467; total, 1,753,389.

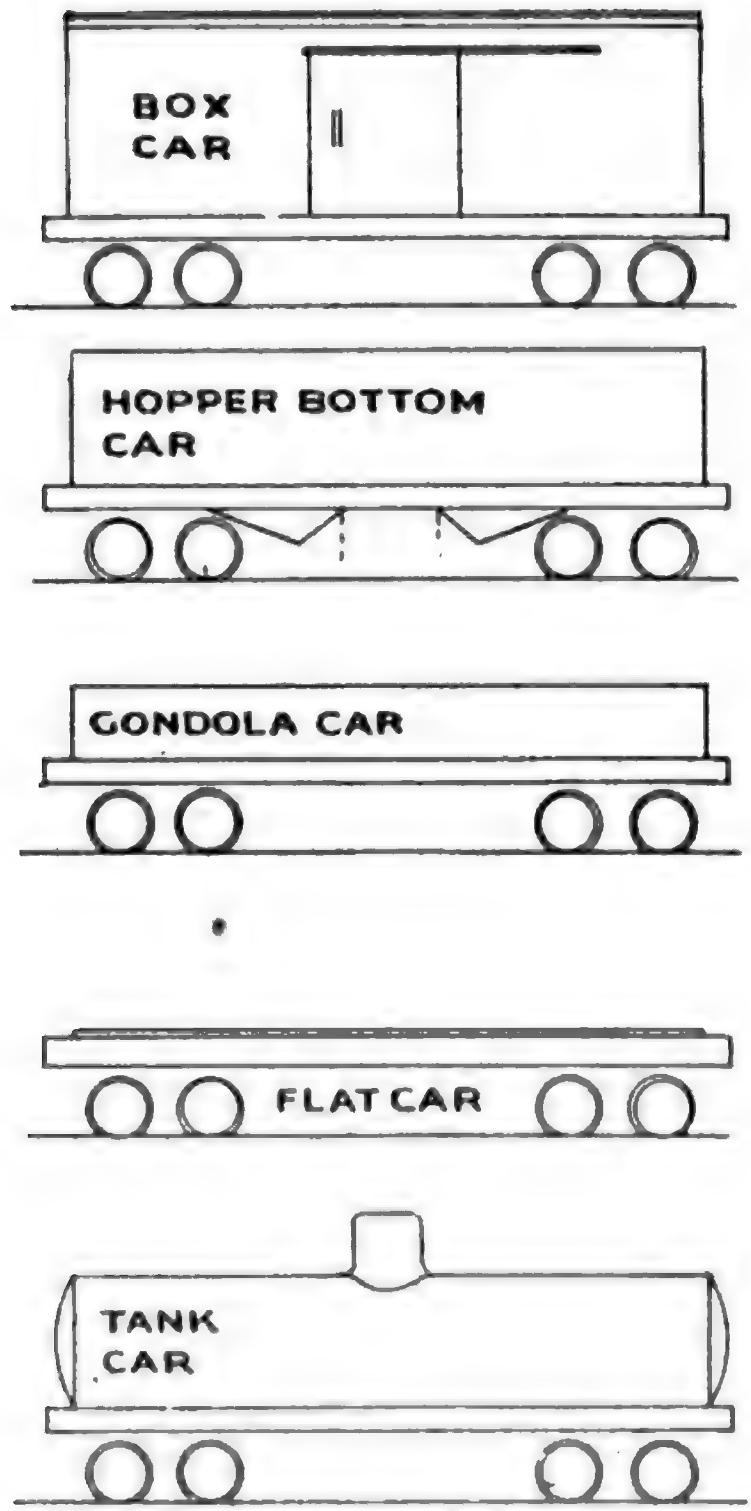
Car Discharge Valve.—Valve on each car having air train signals for discharging air to reduce pressure in whistle line and sound whistle in cab.

Car Bodies.—8 Wheel. Box Cars. 40 ft. long or over, $440; 36 ft. long or over but under 40 ft., $385; 34 ft. long or over but under 36 ft, $360; 43 ft. long or over but under 34 ft., $330; Under 32 ft. long, $265; Extra for Ventilated Fruit Cars, 34 ft. long, $25; Extra for Ventilated Fruit Cars, 36 or 40 ft. long. $30.

Flat Cars.—40 ft. long or over, $200; 32 ft. long or over but under 40 ft., $155; Under 32 ft. long, $110.

Gondola Cars.—Drop Bottom, 40 tons and over, $330; Drop Bottom, 30 tons and over but under 40 tons, $300; Drop Bottom, 25 tons and over but under 30 tons, $275; Drop Bottom, 20 tons or under, $200; Hopper Bottom, 50 tons, $440; Hopper Bottom, 40 tons and over but under 50 tons, $360; Hopper Bottom, 30 tons and over but under 40 tons, $330; Hopper Bottom, 25 tons and over but under 30 tons, $290; Hopper Bottom, 20 tons or under, $220; Plain, 40 tons and over, $300; Plain, 30 tons and over but under 40 tons, $275; Plain, 25 tons and over but under 30 tons, $250; Plain, under 25 tons, $140.

Stock Cars.—34 ft. long or over, $330; 32 ft. long or over but under 34 ft., $300; Under 32 ft. long, $265; Extra for double deck, $25.



Types of Cars.

Car Trucks.—50,000 lbs. Capacity, Wood and Metal, $195; 60,000 lbs. capacity or under, All Metal, $285; 80,000 lbs. Capacity or under, but over 60,000 lbs. (Metal), $360; 100,000 lbs. Capacity or under, but over 80,000 lbs. (Metal), $385. Prices include brake beams complete, truck levers, truck lever guides and bottom connection rods.

Cars—Four-Wheel. Coal Car (ordinary) Complete, $220; Box Car, Complete, $255; Gondola, drop bottom, Complete, $330.

Carline.—Same as Carling.

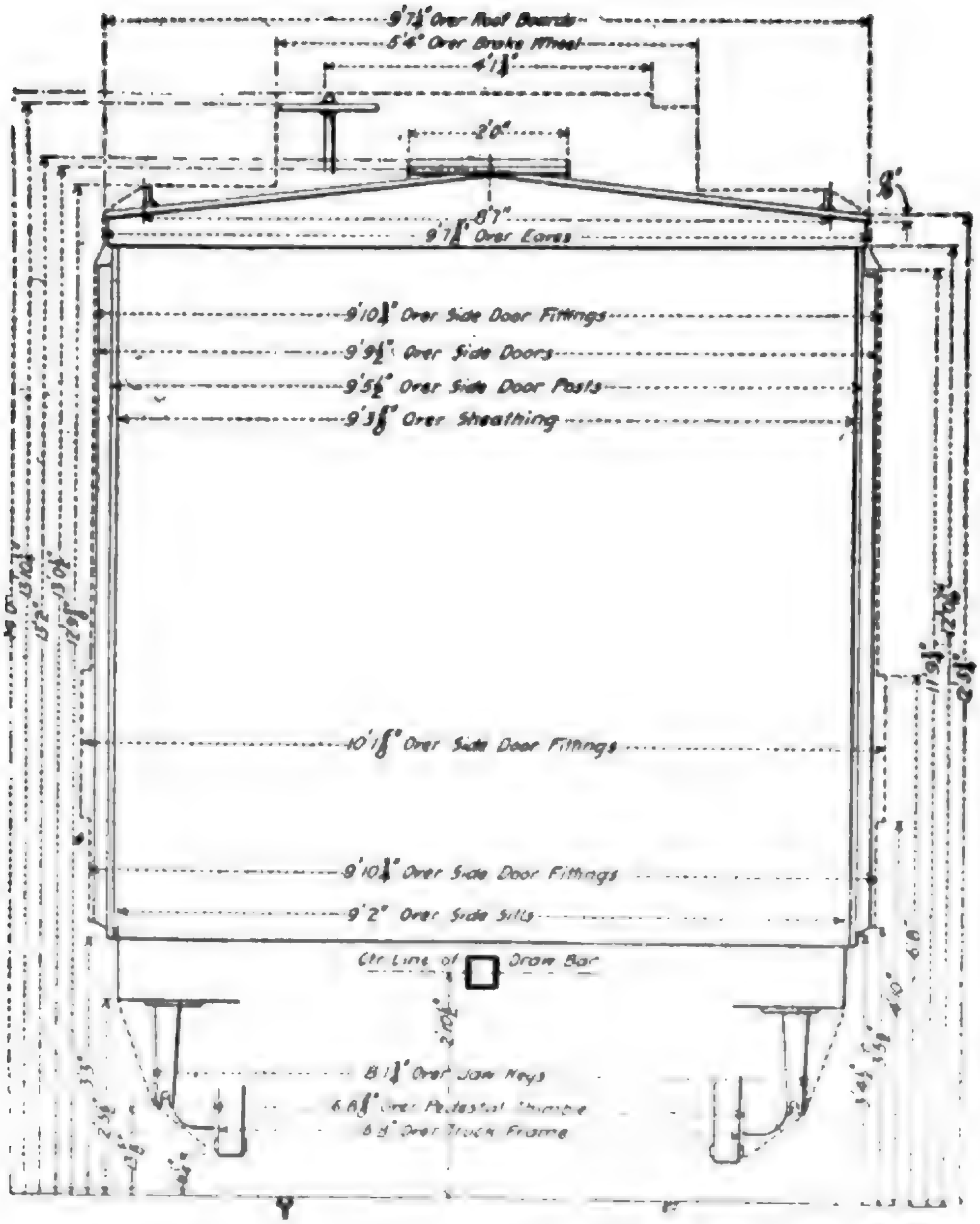
Car-Mile.—One car hauled one mile. A term that was used largely before the "ton-mile" became common. See ton-mile for further explanation.

Cast-Iron Car Wheels, Life of.—Average of two years run of 5,320 cast-iron wheels, 33 inches in diameter, passenger service, gave life of 56,000 miles per wheel. Average mileage per year of freight car was 9,243, so that average life would be about 6 years.

Caulking.—Connery's Method. Formerly a square-cornered caulking tool which was apt to score and injure sheets unless carefully handled. Mr. Connery, formerly a foreman in Baldwin's, introduced a round nose tool instead.

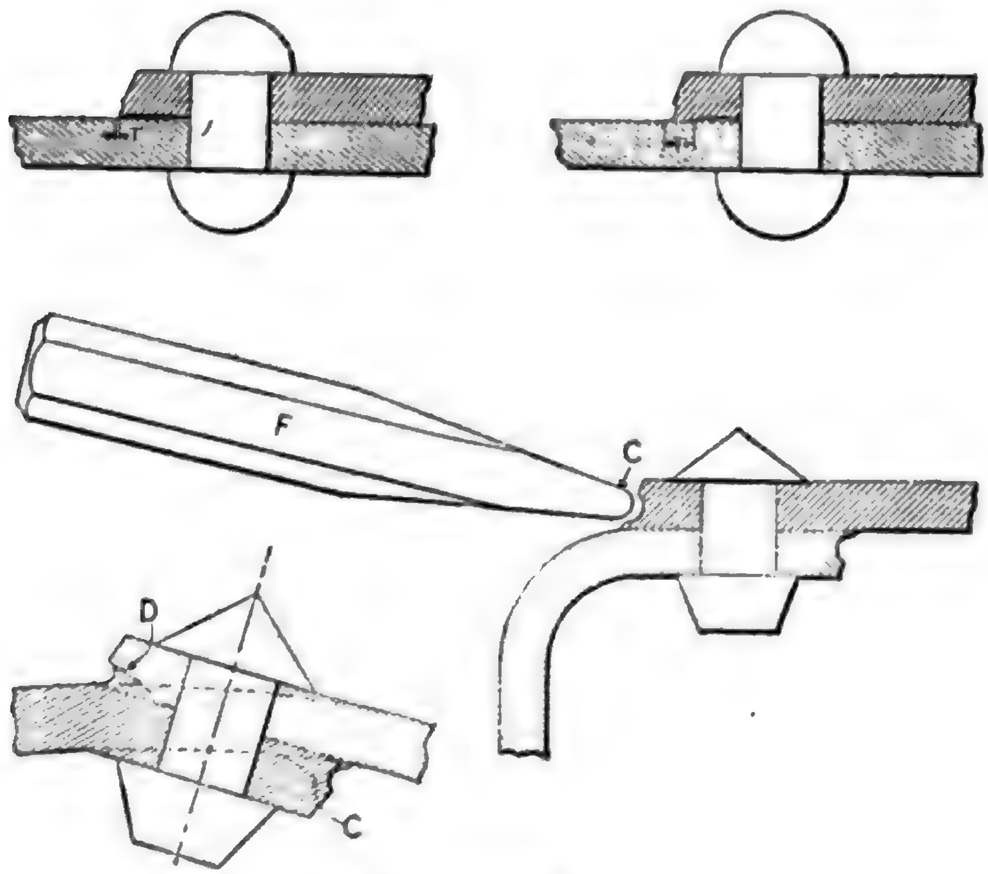
Center Pin.—Pivot about which the truck turns under the car. Also called king bolt.

Center Plate.—Bearing plate between body bolster and truck bolster.



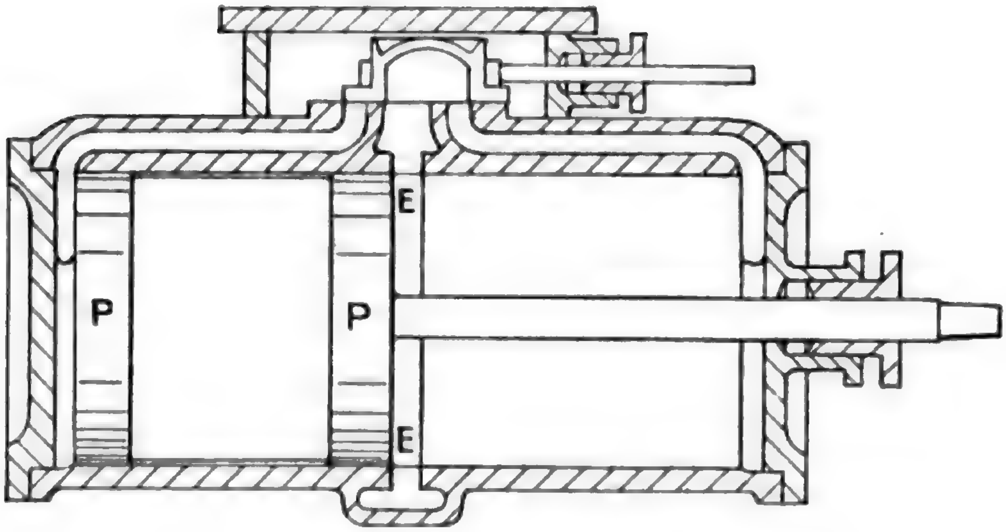
Clearance Diagram, 40-Ton Car.
New York Central & Hudson River Railroad.

Caulking.—The forcing of metal into close contact by means of a kind of blunt chisel and hammer. Used in boiler work in making riveted sheets and flues water and steam tight.



Caulking.

Central Exhaust Locomotive.—A plan whereby the piston is practically a spool as shown. Supposed advantage is that exhaust has no back pressure. First one on record made by Roberts in 1874 for the Lake Shore R. R. Invented again by Cleveland and Peterson who had one built at Baldwin, in 1899, for Intercolonial Ry., of Canada. Later built more at Dickson's; all changed to standard cylinders.



Roberts Central Exhaust, 1874.

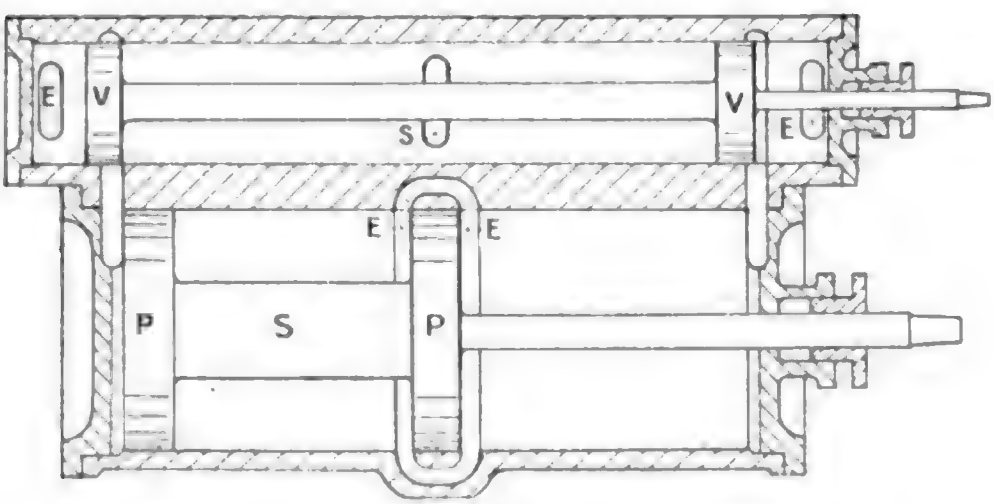
Chafing Block.—See Dead Wood.

Cheek Iron—See Drawbar Stop.

Chilled Wheels.—Average life given as 76,260 miles.

Clearance—See Cylinder Clearance.

Cleveland Central Exhaust Locomotive.—See Central Exhaust Locomotive.



Cleveland's Central Exhaust, 1899.

Chains.—Size of chain is given as diameter of rod used in making links.

Size of Chain Inches	Proof Test B B in pounds	Proof Test B B B in pounds	Proof Test Dredge Chain in pounds	Weight Common Coil Chain per 100 ft.
3/16	1000	1250	1350	50
1/4	2000	2350	2450	75
5/16	2800	3300	3500	110
3/8	4450	5200	5500	155
7/16	5650	6540	7100	200
1/2	7100	8550	9550	265
9/16	8900	10800	12500	325
5/8	12000	14800	16000	420
11/16	14500	17000	18500	500
3/4	18070	22000	23000	590
13/16	21000	24000	25000	700
7/8	24100	27100	28500	800
15/16	29000	29200	31000	900
1	30120	34100	35500	1000
1 1/16	33000	38100	40750	1100
1 1/8	36150	44130	46000	1250
1 3/16	38500	47130	49000	1400
1 1/4	42130	52160	54000	1600
1 5/16	45000	56200	58500	1750
1 3/8	48200	62200	64000	1900
1 7/16	51500	67000	70000	2100
1 1/2	56190	74120	77000	2100

Safe working load should be about one-half the above. The breaking strain is about double the above.—Jeffrey M'f'g. Co.

Coal.—Anthracite—All coal with less than 7.5 per cent. volatile matter in combustible. Semi-Anthracite—From 7.5 to 12.5 per cent. Semi-Bituminous—From 12.5 to 25 per cent. Bituminous—From 25 to 50 per cent. Lignite—All over 50 per cent.

Coal.—Anthracite—Hard, slow burning coal, composed of carbon 80 to 86 per cent; ash 4 to 12 per cent.; sulphur 1-2 to 1 per cent.; water 1 to 4 per cent. and volatile matter 3

to 7 1-2 per cent. Weighs 54 lbs. per cubic foot and occupies 37 cubic feet per ton of 2000 pounds. Bushel weighs 78 lbs. Specific gravity 1.70.

Coal.—Bituminous—Average bituminous coal contains about 80 per cent. of carbon, 5 per cent. of hydrogen, 15 per cent. of other substance generally considered as forign matter or impurities; ignites at about 1800 degrees and weighs about 52 pounds per cubic foot. One ton of 2000 pounds occupies 39 to 40 cubic feet. A bushel of 2500 cubic inches weighs 75 pounds. Specific gravity 1.40.

Coal.—

	B.T.U. per lb. Combustible	Ash per cent	Moisture per cent
Anthracite	14,700	10 to 20	1 to 5
Semi-anthracite	14,900	10 to 20	1 to 5
Semi-bituminous	15,800	5 to 10	1 to 6
Bituminous—Eastern	15,000	5 to 20	2 to 6
" Western	14,200	8 to 25	6 to 15
Lignitæ	12,200	5 to 20	10 to 30

Coal Consumption.—Varies greatly with different conditions of trains, roads, locomotives, etc. Exact comparisons are impossible unless we know all conditions, which is seldom the case. Tests on several roads running into New York, in 1897 give these results: Hard Coal: Average per train mile, 17.3 freight cars, 122 lbs.; average per train mile, 7 passenger cars, 112 lbs.; average per freight car mile, 7.05 lbs.; average per passenger car mile, 16. lbs. Soft Coal.—Average per train mile, 18.15 freight cars, 120 lbs.; average per train mile, 7 passenger cars, 110 lbs.; average per freight car mile, 6.06 lbs.; average per passenger car mile, 15.07 lbs.

Coal Consumption of Locomotives.—Mallet compound on B. & O., weight 479,500 pounds, 9.26 miles per ton (2,000 lbs.), run of mine bituminous coal.

Consolidation, 20×26; load, 1,440 tons, 33 cars; 74 miles.

Coal, per ton mile........................ .0971 lbs.
Steam, per ton mile........................ .610 lbs.

Coffin Process.—Name given to a process of toughening steel, introduced by Mr. John Coffin, of the Cambria Steel Co. The steel is first heated to a certain temperature, then cooled in such a way as to destroy any crystalline forms and make it a very tough and ductile metal.

Combustion.—The union of oxygen (atmosphere) with the carbon and other elements composing the fuel. Commonly known as burning.

Combustion.—Heat of. Resulting temperature of combustion is calculated to be as follows: Anthracite 4100 to 4200 deg. Fahr.; Bituminous, 4000 to 4100 deg. Fahr.; Coke and Charcoal, 4300 to 4400 deg. Fahr.

Compound Engine.—A multiple expansion engine of two stages. The low pressure or second stage may be divided between two or more cylinders.

Compound Locomotive.—See Locomotive-compound.

Compression.—The pressure resulting from the piston compressing the steam remaining in the cylinder after exhaust closes. Takes power but cushions engine over the center and helps warm up the cylinder.

Condenser—Jet.—In these the steam and water mingle, the resulting hot water going to a hot well. From here it is pumped out by the air pumps.

Condenser—Surface.—Condenser in which the steam does not come in contact with the cooling water. It is usually confined to the space surrounding the tubes through which the cooling water is pumped. Water required is about 25 to 30 times steam to be condensed by weight.

Condenser—Syphon.—A jet condenser in which the water from the hot well is removed by syphon or ejector instead of a pump.

Conduction of Heat.—The passing of heat from one particle to the other, in a piece of metal or other material. If one end of a piece of iron is put in the fire, the heat soon passes along the piece. In some metals this is more rapid than in others. Those which pass it the quickest are the best conductors.

Consolidation.—Locomotive with a pony truck and 8 coupled drivers. Designed by Alexander Mitchell for the Lehigh Valley R. R. in 1866.

Contraction of Area.—As a piece of metal stretches under test, the area of course diminishes or contracts until the piece finally parts. This varies largely but may be said to average 40 per cent. for steel.

Corundum.—An abrasive material. Found as a natural product, similar to emery.

Cost of Operation.—See Railroad Operation.

Concentric.—When two circles are drawn from the same center they are called concentric. One tube in the center of another is said to be concentric.

Concrete Tie.—Designed by Mr. R. B. Campbell in 1904. Rectangular section, 7 in. wide, 6 in. deep with beveled corners—enlarged under rail to 10 in. wide, 8½ feet long. Reinforced by two old boiler tubes, 2¼ inch by 7 feet long surrounded by hen netting. Tubes slotted under rail and heavy netting inserted. Cost $1.50 to $1.75 each, weigh from 293 to 401 lbs.

Condensation.—When water is heated until it becomes steam it expands greatly, to 1646 times its bulk at the pressure of the atmosphere. On being cooled it "condenses" to its original volume and becomes water. Steam condenses on striking the cool walls of the cylinder and this is one source of loss.

Condensing Engine.—One in which the exhaust is condensed back to water instead of being allowed to escape as steam. This adds to the power of the engine by producing a partial vacuum on the exhaust side of the piston. Condensing engines require over 20 times the water for producing condensation that they do for making the steam and this is not practicable for locomotives.

Condenser.—Apparatus for condensing the exhaust to reduce the back pressure below atmospheric pressure, as this adds to the effective pressure on the piston. There are three kinds—jet, surface and syphon or ejector.

Cost of Operation of Railways.—See Electrical Operation of Railways and Railroad Operation.

Cost—Locomotive Running.—Mallet compound on B. & O.—479,500 lbs.—74,000 to 84,000 lbs. drawbar pull—cost $24.50 per 100 miles for fuel, water, repairs, wages, hostlering, lubrication, etc. Electric locomotive of same capacity cost $34.50 per 100 miles, including electric current, wages, lubrication, etc.

Cost of Repairs.—See Locomotives and Cars.

Cost of Stopping Trains.—For passenger trains of seven and eight cars, total weight including engine and tender half loaded about 530 tons, the various items of stopping and starting, from and to a speed of 50 miles per hour are estimated as follows:

Coal to stop train (air pump)	30 lbs.
Coal to accelerate train	275 lbs.
Total coal	305 lbs.
At $2.15 per ton	$0.33
Brake shoe wear, tire wear	0.03
Brake rigging wear, draft rigging wear, miscellaneous	0.06
Total	$0.42

The cost of stopping and starting a 2,000-ton 80-car freight train from and to a speed of 35 miles per hour would not be far from $1, itemized as follows:

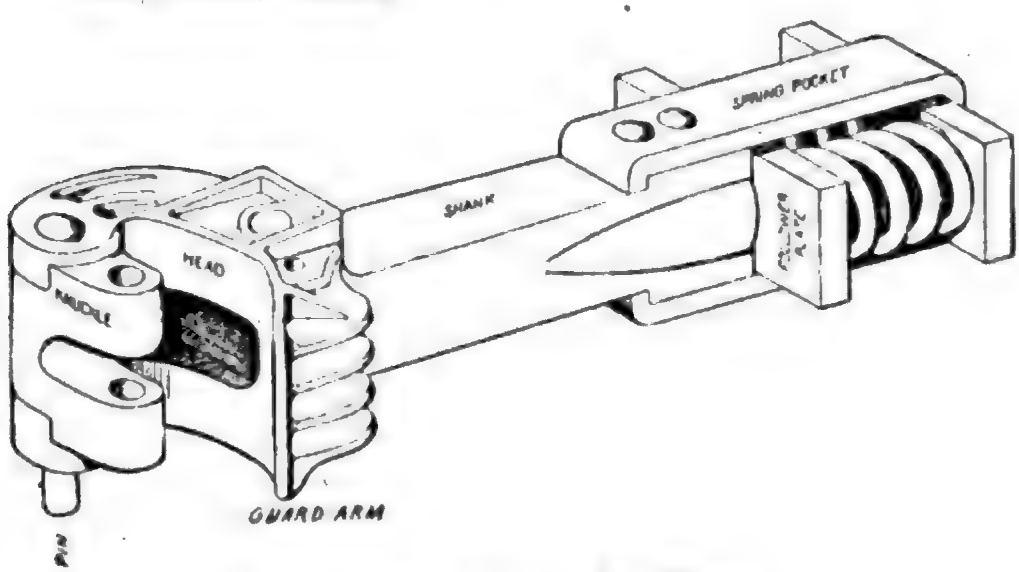
Coal to stop train (air pump)	50 lbs.
Coal to accelerate train	500 lbs.
Total coal	550 lbs.
At $2.15 per ton	$0.56
Brake shoe wear	0.15
Other items (as classified above)	0.29
Total	$1.00

J. A. Peabody, Signal Engineer, C. & N. W. Ry.

Cotters.—See Split Key.

Coupler: M. C. B.—A type adopted by the Master Car Builders' Association and known as the "vertical plane" coupler because coupling car-faces are vertical. There are many designs of M. C. B. couplers.

M. C. B. Standard Gauges of all kinds may be had from Pratt & Whitney Company, Hartford, Conn.



Couplers.—M. C. B. Type.

Couplers.—Limit of Wear. Must not exceed 5⅛ inches between guard arm and point of knuckle. Full length of wheel defect gage is used, which see for gage.

Counterbalancing.—First used by Thomas Rogers (Rogers Loco. Works). Patented July 12, 1837.

Counterbalancing Locomotive Driving Wheels.—M. M. rule for.

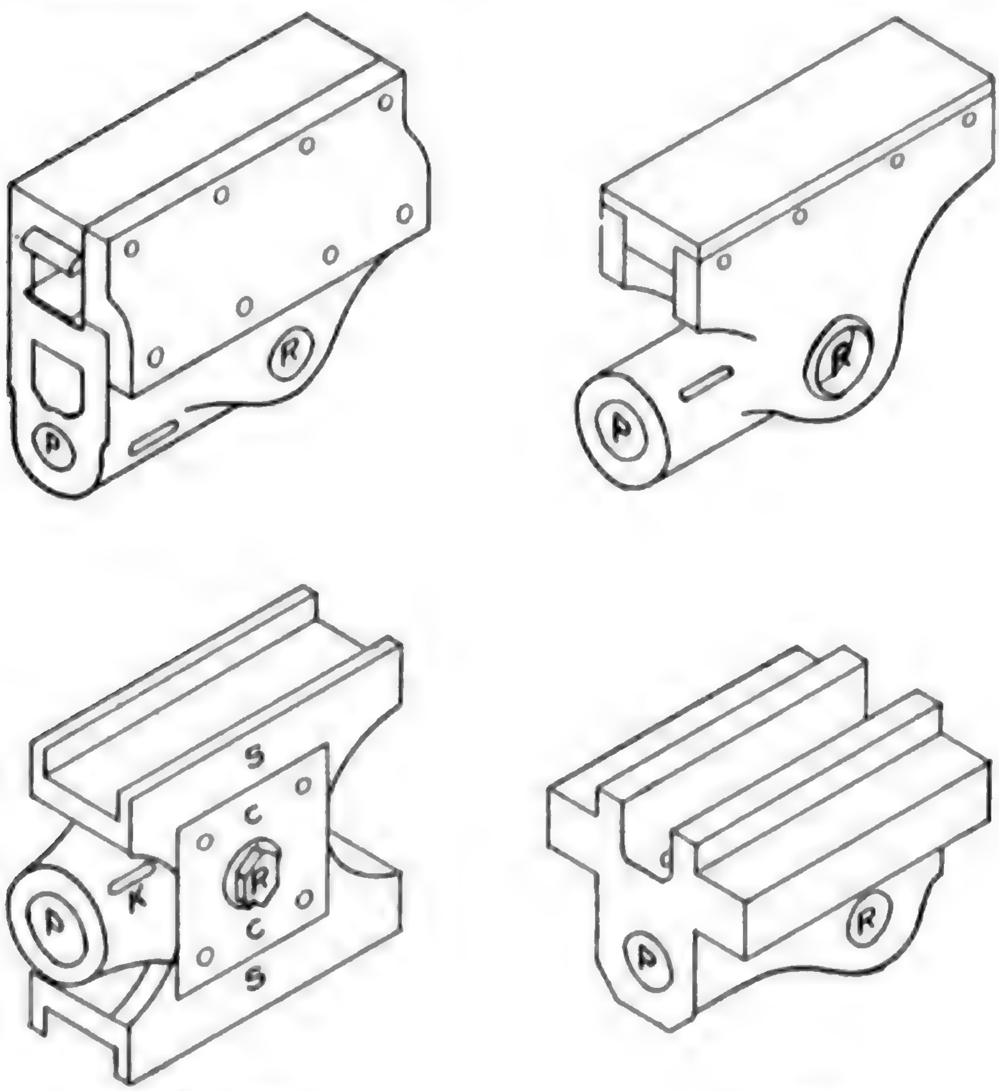
First.—Divide total weight of engine by 400. Subtract quotient from weight of reciprocating parts on one side, including front end of main rod.

Second.—Distribute the remainder equally among all driving wheels on one side, add-

ing to it the weight of revolving parts for each wheel on that side. The sum for each wheel, if placed at a distance from driving wheel center equal to length of crank, or a proportionally less weight if at a greater distance, will be counterbalance required.

Cow Catcher.—See Pilot.

Crossheads.—Types of.—



Single Bar Guide. Laird.

Alligator. Four Bar Guide.

Crampton Locomotive.—Designed by T. R. Crampton for the London and Northwestern, built by Bury, Curtis & Kennedy, of Liverpool, in 1848. With a single pair of drivers behind firebox.

Crank Pin.—Pin in driving wheel by which it is driven. Rod bearings go on crank pin and drive the wheel.

Cross Compound.—An engine with a high pressure cylinder on one side and a low pressure on the other. Usually have a receiver or reservoir between the two. In locomotive work these are often called "two cylinder" compounds.

Cross Compound.—See Locomotive.

Crossed Rods.—See section of link motion.

Culm Burner.—A name given to locomotives having a very large grate area. Designed to burn "culm" or screenings from coal, which must be burned at a very low rate per square foot of grate. Some of these grates have been 9′ 6″ wide by 10′ 6″ long or an area of 99.75 square feet.

Cupola.—Refers to observation portion of a caboose, sometimes called a cabin or lookout.

Curves.—The simplest way of describing a railroad curve is by giving the length of the radius, i. e., the distance from the center to the outside of the circle, or one half the diameter. The shorter the radius the sharper the curve. The length of the radius is usually stated in feet. English engineers often state the radius in chains (one chain = 66 feet). The length of the radius of a railroad curve is measured to the center of the track.

Civil engineers designate railway curves by degrees (using the sign ° for degrees and " for minutes, there being 60 minutes in one degree).

The exact length of radius which with an angle of one degree has a chord of 100 feet is found to be 5729.65 feet. For sake of convenience 5,730 feet is usually taken as the radius of a one-degree curve. If the angle at the point of the V is two degrees and the sides are prolonged until 100 feet apart, the length of each side is (almost exactly) one half as long as when the angle is one degree, or ½ of 5,730 = 2,865 feet. For a three-degree curve the radius is 1-3 of 5,730, and so on. For perfect exactness the length of 100 feet should be measured not along a straight line connecting the ends of the V but along the line of the circle of which the sides of the V are radii; i. e., the arc should be used and not the chord. The difference, however, is so slight for any curves ordinarily used on main lines of standard gauge railroad as to be ignored in practice.

For extremely sharp curves, or say 100 feet radius or less, it is usual to express the curve by feet radius rather than by degrees. The table following is computed by the formula $R = \frac{5730}{D}$, and fractions of feet are not taken into account.

A chord of 213 1-2 feet shows one degree of curve for every foot between chord and rail at center. Take a line 213 1-2 feet long and tie a knot in the center; stretch on the inside of outer rail and measure distance between knot and rail. This in feet equals degrees. If 18 inches it equals 1 1-2 degrees.

Dividing 5730 by the number of degrees gives radius in feet.

Curves.—Widening Gage on. The gage or distance between rails is increased on curves to prevent flange friction. One rule is to widen gage 1-16 of an inch for each 2½ degrees of curve.

CURVES.

Degree.	Radius in feet	Equivalent to a Grade of (Feet per Mile.)
1	730	1.32
2		2.64
3	8	3.96
4	1	5.28
5	1146	6.60
6	955	7.92
7	819	9.24
8	717	10.6
9	637	11.9
10	574	13.2
12	478	15.8
14	410	18.5
16	359	21.1
18	320	23.8
20	288	26.4
22	262	29.
24	240	31.7
26	222	34.3
28	207	37.
30	193	39.6

Curve Resistance equals 1-2 pound per degree curve.

Equivalent Grade is 1.32 feet per mile for every degree curve.

Radius in feet equal 5730 divided by degrees —very nearly. Not quite true for short curves.

Curves—Compensation for. Grades are sometimes reduced on curves so that combined resistance of grade and curve will not exceed that of steepest grade on straight track. This is done by allowing 2-100 of a foot grade in a 100 feet for each degree of curve. For very sharp curves the allowance is increased to 3-100 of a foot per 100 feet.

Curves.—Elevation of Rail. It is necessary to elevate outer rail on curves to overcome tendency of a train to tip over rounding a curve at speed. Roadmasters recommend the following elevation:

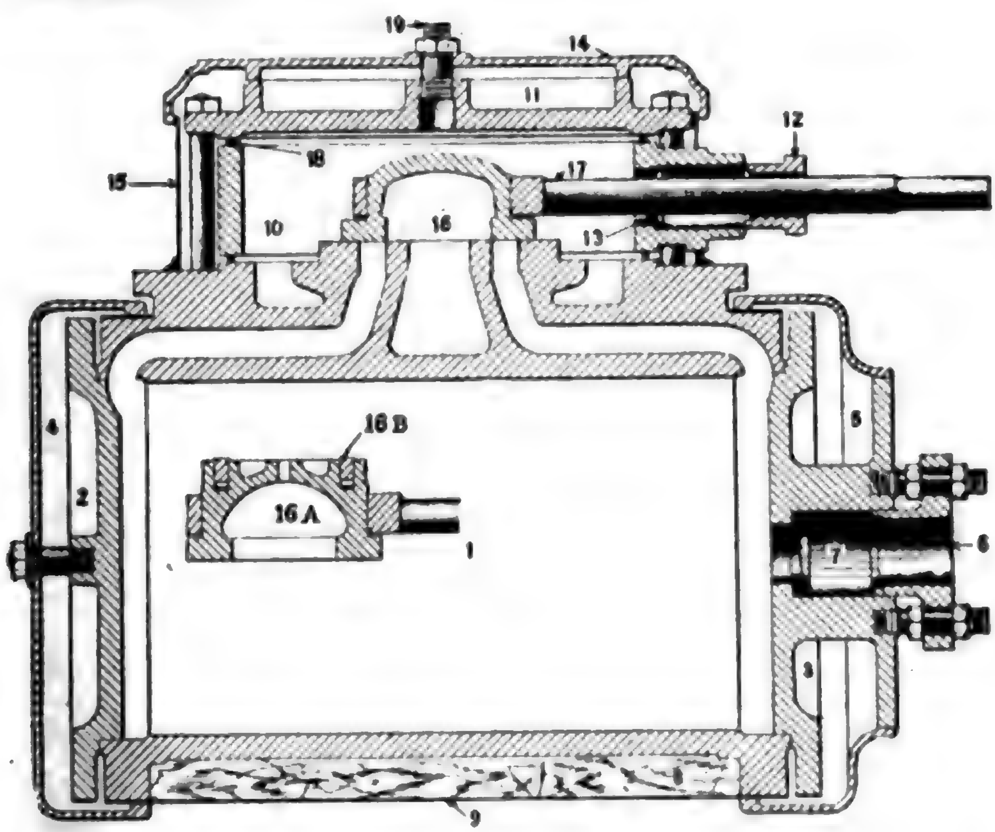
ELEVATION OF OUTER RAIL IN INCHES AND FRACTIONS.

Radius in Feet.	Degree of Curve.	Level or ascending grade. Speed 40 miles per hour.	Descending grade. Speed 50 miles per hour.
	0° 30′	0 ¾ in.	1 in.
5730	1 00	1 ½	1 ¾
	1 15	1 ¾	2
	1 30	2	2 ¼
	1 45	2 ¼	2 ½
2865	2 00	2 ⅜	2 ¾
	2 15	2 ⅝	3
	2 30	2 ⅞	3 ¼
	2 45	3	3 ⅜
1910	3 00	3 ⅛	3 ⅝
	3 15	3 ⅜	3 ⅞
	3 30	3 ⅝	4
	3 45	3 ⅞	4 ⅛
1432	4 00	4	4 ½
1146	5 00	4 ⅞	5 ⅜
955	6 00	5 ⅝	6 ⅛
819	7 00	6 ½	7
716	8 00	7 ⅜	7 ⅞

Curve.—Transition.—A curve which changes its shape gradually from a large radius to a smaller one. Used very largely on double-track roads where trains run but one way as it makes an easy riding curve and one which can be taken at high speed.

Cut-off.—Point at which steam is cut off and left to do its work by expansion. This varies according to locomotive and work it is doing, but rarely earlier than 1-5 or later than 7-8.

Cylinder.—



1—Cylinder, 2—Front head, 3—Back head, 4—Front, 4-5—Front and back casing cover, 6—Gland, 7—Bottom ring, 8—Wood lagging, 9—Casing, 10—Steam chest, 11—Cap, 12—Gland, 13—Bottom ring, 14—Casing cover, 15—Casing, 16—Valve (plain D), 16A—Balanced D valve, 16B—Packing strips, 17—Yoke, 18—Steam chest joint, 19—Oil pipe stem.

Cylinder Clearance.—The space in cylinder and steam ports between piston head (when at extreme end of stroke), and valve face. Generally given in percentage of cylinder and in locomotive work varies from 10 per cent. to 20 per cent. This is space which must be filled each stroke, and which does no useful work. Some clearance is necessary to prevent piston striking cylinder head and space is necessary for compression to cushion piston at end of stroke.

Cylinder Ratios.—See Ratios of Cylinder.

D

Dead Center.—Two points in the revolution of every crank when the pressure applied to other end of rod acts directly against the axle or shaft. In these positions it has no tendency to turn the crank in either direction.

Deadwood.—Blocks which take the shock of cars bumping together. Placed each side of drawbar. Also called dead block, buffer block, bunter block, chafing block and head block.

Dead Block.—See Deadwood.

Decapod.—Locomotive with a pony truck and 10 coupled drivers. Built in 1885.

Deflector.—Arrangement to force air or gases down. Sometimes used on inside of fire door and nearly always in front end to deflect gases coming through flues. See Hudson's Fire Door Deflector.

Degree of Curve.—A one-degree curve has a radius of 5730 feet. See Curves for details.

Derailing Swith.—Commonly called simply "derail." A switch connected with the signal system which will run train on ground

if signal is set against it. Used to protect crossings and other dangerous points.

Double Acting Engine.—Engine in which steam acts on both sides of piston alternately; i. e., first on one side and then the other. All locomotives are double acting.

Draft.—The intensity of the draft or blast on the fire is much stronger on locomotives than elsewhere.

Stationary boilers vary from 1 to 1.4 inches of water.

Naval, under forced draught, 1 to 4 inches.

Locomotive, 3 to 10 inches.

Allowing 1 inch to represent .04 pounds per square inch, or 5.2 lbs. per square foot, we have

	Draft in Pounds.	
	Per Sq. Inch.	Per Sq. Foot.
Stationary	.004 to .014	.52 to 7.28
Naval	.04 to .16	5.2 to 20.8
Locomotive	.12 to .14	15.6 to 52

Draft Arm.—See Draft Timber.

Draft Lock.—See Draft Timber.

Draft Spring.—Spring behind draw bar to take up shock of starting train. Also called draw spring and bumper spring.

Draft Timber.—Timber across car which takes the pull of the draft gear. Also called draw stick, draft block, jaw block, knee timber, draft arm.

Drawbar—Bar fixture by which car is drawn. Same as drawhead, pull-iron, shackle-bar, bull-nose.

Drawbars.—Standard height of drawbar is 34½ inches when car is empty and 31½ inches when loaded. This distance is measured from the top of the rails to the center of the drawbar shank. A variation of ¼ inch is allowed. Care should be taken in adjusting a loaded car so that its height will be right when empty.

Drawhead.—See drawbar.

Drawbar Stop.—Stop limiting movement of drawbar under pull. Also called follower stop, check iron and lug iron.

Draw Stick.—See draft timber.

Drifting Valve.—See By-pass.

Drills.—Twist drill experiments at Worcester Polytechnic Institute by Bird and Fairfield in 1904.

Brass. Thrust 190 lbs. Speed 260. Feed .008″ per rev. 60″ lbs. moment.

C. I. Thrust 330 lbs. Speed 260. Feed .008″ per rev. 84″ lbs. moment.

Tool Steel. Thrust 560. Speed 260. Feed .008″ per rev. 140″ lbs. moment.

M. Steel. Thrust 860 lbs. Speed 260. Feed .008″ per rev. 205″ lbs. moment.

Power required varies directly with the revolutions. Thrust varies as the feed or advance per revolution.

Drills—Cutting angle. Standard angle is 59 degrees. Tests by Bird and Fairfield at Worcester Polytechnic Institute indicate that for the newer high speed steel 45 degrees would be better as it stands up as well and does the work with much less thrust.

Driving Wheel Base.—Distance between centres of front and rear drivers.

Driving Wheel Clearance.—For proper clearances the minimum outside diameter of driving-wheels should ordinarily be not less than twice the length of stroke.

Drop Test.—A method of testing axles, etc., one axle being selected from each melt and tested. And sample failing to meet the test rejects the whole melt.

Points of supports for axles must be 3 feet apart, center to center. Drop must weigh 1640 pounds; anvil 17,500 pounds, must be mounted on 12 springs and free to move vertically.

Dunbar Packing—See Piston Packing.

E

Eccentric.—The substitute for a crank used to give motion to the valve, through the link and rocker arm. See diagram of link motion.

Eccentric Rod Pin.—Pin connecting eccentric rods to link.—Placed back of link arc on regular link; on the link arc in either box link or open link.

Ejectors.—A jet apparatus for lifting or forcing water or both. With about 60 pounds of steam water can be lifted 25 feet and forced up 15 feet more. To raise water higher the ejector should be placed near the water so that the actual "lift" will be very low.

Ejectors.—Water Pressure.—The ejector will work with water pressure instead of steam pressure as the motive power, as above stated, and when used this way are very efficient.

With 20 pounds of water pressure they will lift 5 feet. With 30 pounds of water pressure they will lift 12 feet, and with all pressures above 40 pounds will lift 20 feet.

When working under water pressure, they

will lift and elevate about one-half the quantity of water that would be delivered when using steam.

Elastic Limit.—When a strain is applied to a piece and on removal it returns to its original limit, it is within the elastic limit." When the strain makes a "permanent set" or reaches the yield point, it is beyond the elastic limit. The point at which material will not return to its originanl condition on release of load.

Electrical Operation of Railways.—Mr. B. T. Arnold, E. E., estimated, 1904, that the cost per mile on the New York Central would be 23.6 cents including fixed charges. Cost of steam locomotive was 24.2 cents. Fixed charges for steam locomotive operation were 1.1 cents against 7.8 cents for electric.

Elongation.—The amount a test piece stretches before breaking. The standard test pieces being 2 inches between shoulders; if the piece stretches one-half inch before breaking the elongation will be 25 per cent.

Emery—A universal abrasive used for all sorts of grinding operations from rough castings to dentistry on teeth.

Engineer's Auxiliary.—See Equalizing Auxiliary.

Enlarged Wheel Fit.—See Wheel fit—enlarged.

Engine Truck.—See Trucks.

Equalizers.—Levers for distributing the weight of a locomotive over the driving wheels or over all the wheels as the case may be. First used by Eastwick & Harrison on the "Gowan & Marx" in 1839. These were patent-

ed in 1838 by Joseph Harrison, Jr. This firm also brought the blower into use, designed the first quartering machine and made a crude cab.

Equalizers and Springs.—1. Forward driving spring. 2 to 5. Second to fifth driving spring. 6. Forward truck equalizing beam. 7 to 10. First to fourth driving equalizing beam. 11. Forward equalizing beam link. 12. Fulcrum. 12A. Driving equalizer fulcrum. 13. Driving spring link. 14. Staple. 15. Forward truck center pin bolt. 16. Transverse equalizing beam.

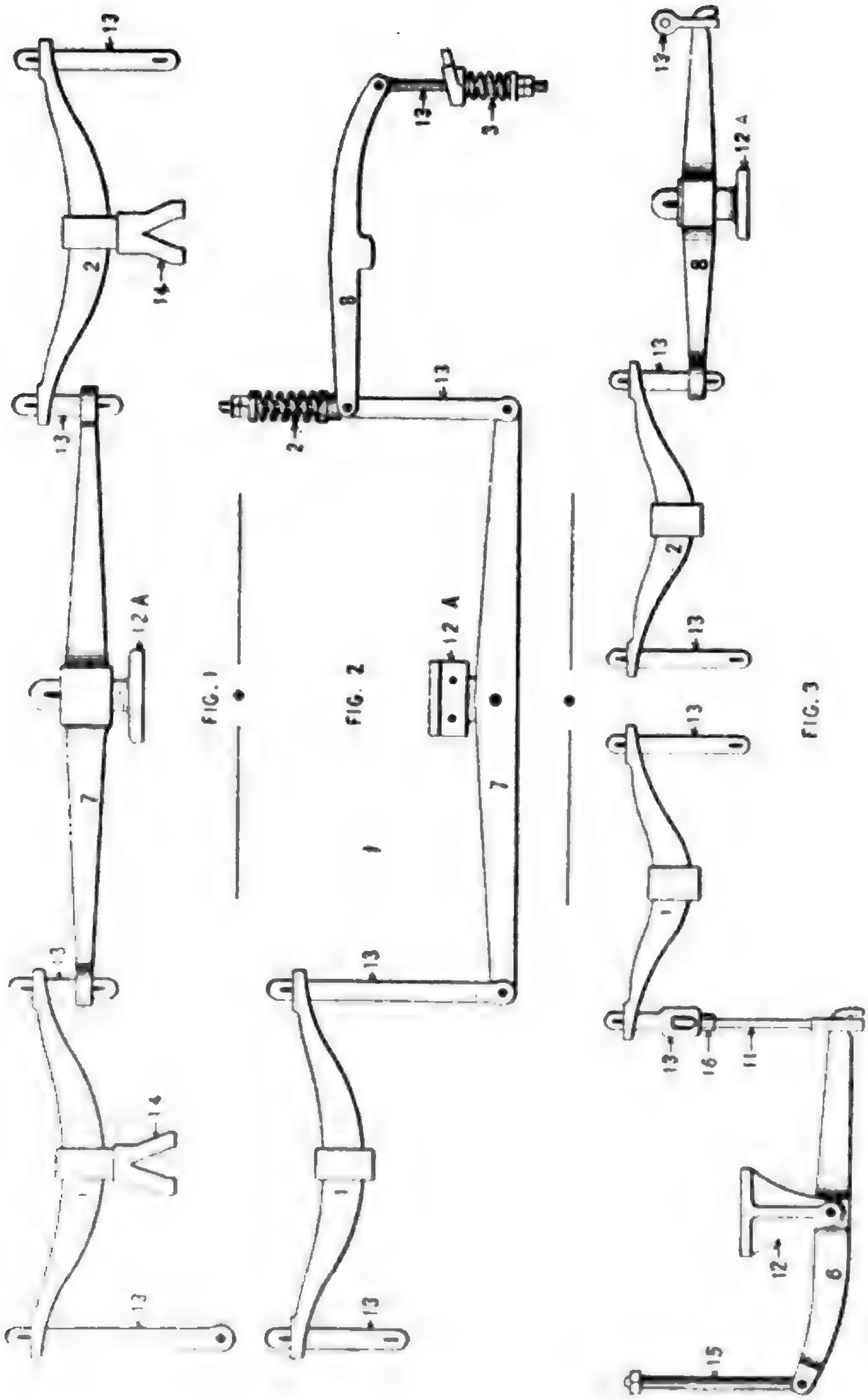


FIG. 1

FIG. 2

FIG. 3

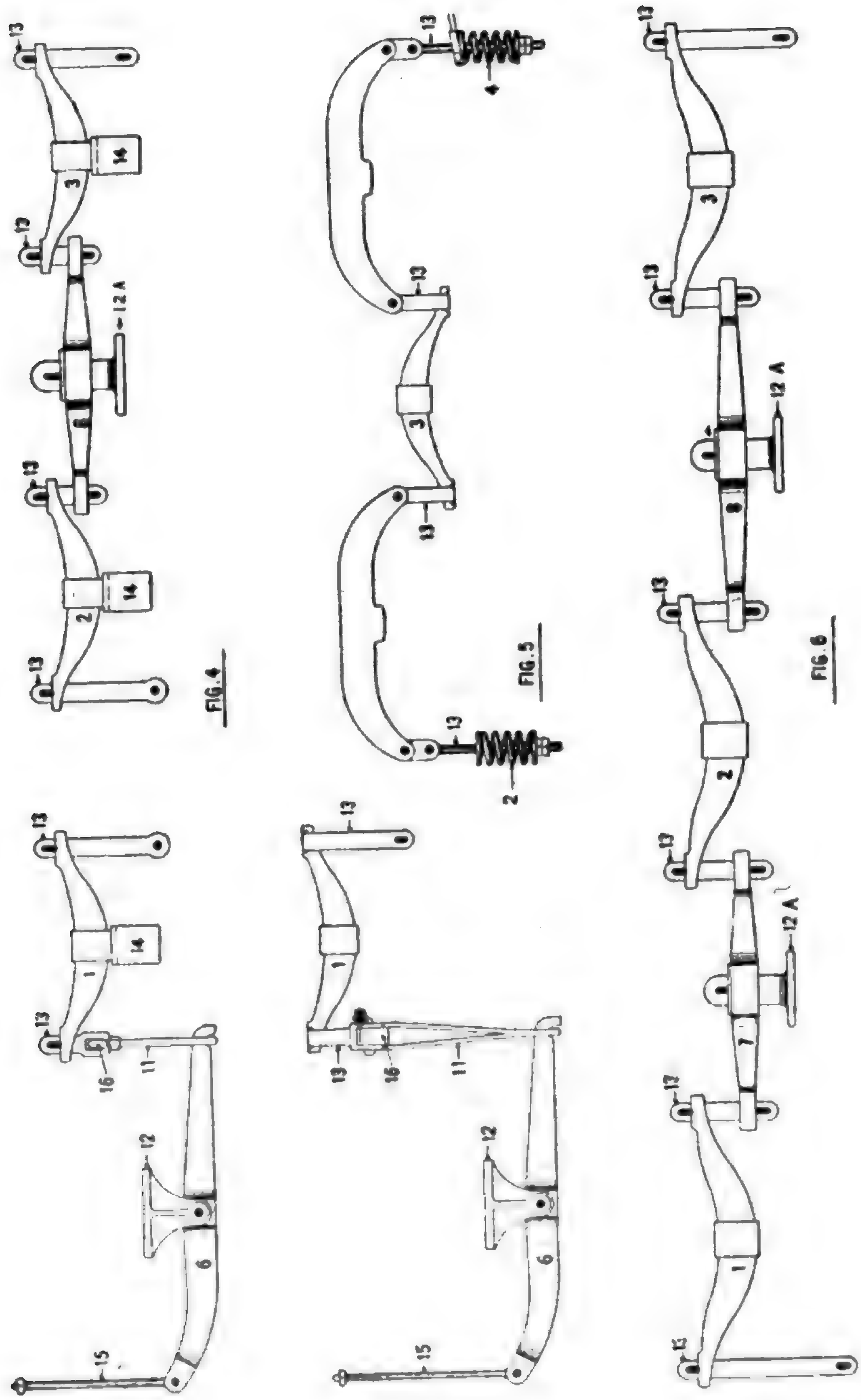


FIG. 4

FIG. 5

FIG. 6

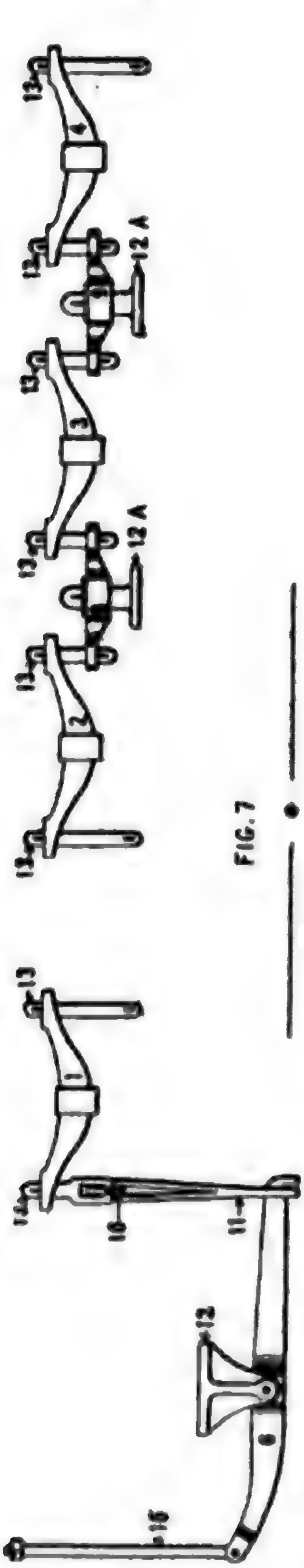


FIG. 7

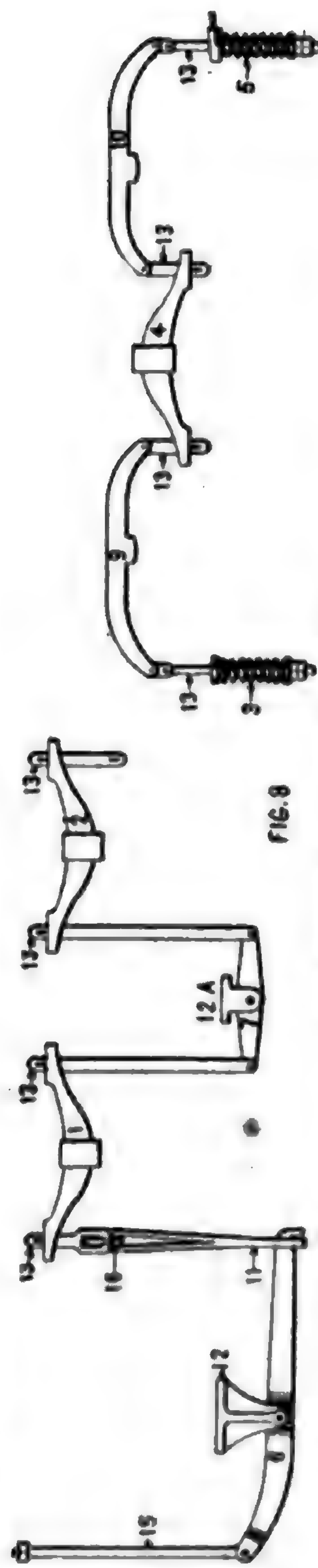


FIG. 8

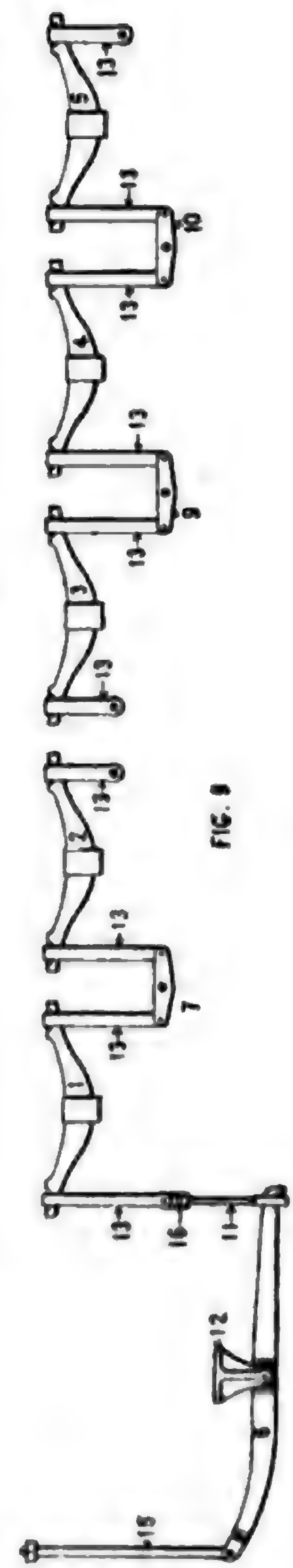


FIG. 9

Evaporation.—The making or turning of water into steam by boiling. In a locomotive boiler the evaporation is very rapid. The number of pounds of water evaporated for every pound of coal burned is called the rate of evaporation. This varies from 4 to 12 pounds with 6 to 7 as a fair average under good condition.

Evaporation.—Factor of. Considering average steam pressure and temperature of feed water in locomotive practice, the factor of evaporation is taken at 1.2, i. e., actual amount of water evaporated, multiplied by 1.2 gives equivalent evaporation from and at 212 deg.

Exhaust Tip. A removable or separate piece for exhaust nozzle to allow for changing the area of the exhaust opening.

Exhaust Thimble—See exhaust tip or bushing.

Exhaust—Variable:—Means for varying area of exhaust nozzle to suit different conditions in working a locomotive. Various kinds have been used and patended. Winans used a cone plug in center of single exhaust as early as 1860, and Milholland later.

Expanders—See tube expanders.

Expansion of steam:—Steam is a very elastic fluid and expands rapidly if permitted to do so. When steam is cut off in a cylinder before the end of the stroke it expands from that point to end. Pressure reduces in proportion to expansion, that it, if a cubic foot of steam at 100 lbs. is allowed to expand to four cubic feet the pressure falls to 25 lbs.

Expansion Pad:—A plate riveted on outside of firebox, which supports it on the frame, but allows it to move back and forth as it expands, and contracts with variations of temperature.

Expansion of Rails.—This is seldom more than ⅜ inch in a 30-foot rail. It will average about 1-16 inch for every 25 degrees' change of temperature.

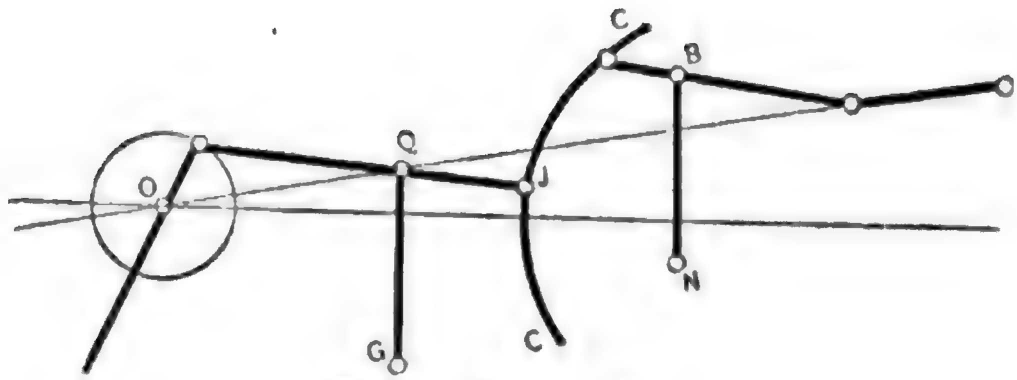
F

Factor of Safety.—If a boiler of such material and strength that it will stand a pressure of 500 pounds before bursting is run at 100 pounds pressure, the factor of safety is 5. In other words, the proportion between the bursting or breaking strength and the pressure or load carried.

Feed-Water Heater:—Arrangements of pipes through which feed water passes to be heated by the gases going out of stack or by exhaust steam. Many kinds have been tried. But in no case has the saving equaled the cost. They have been abandoned in every case. One of the plans that look feasible, but has never proved satisfactory.

Fink Gear.—See Link motion.

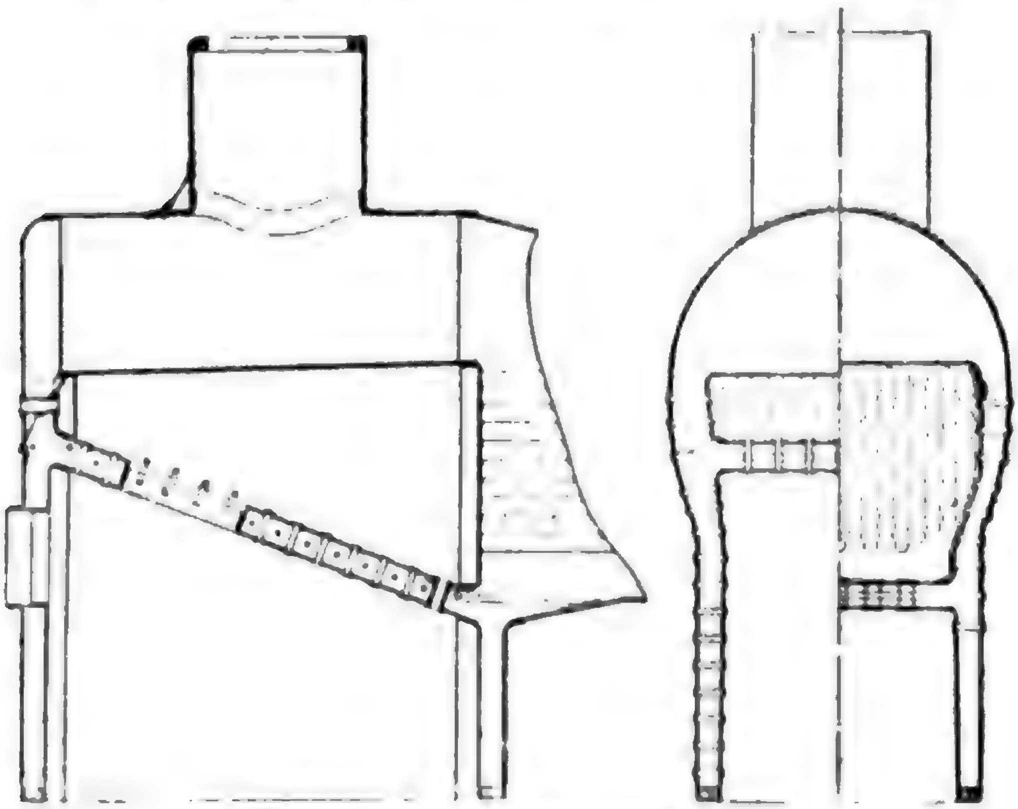
Fink Gear.—Designed by Pius Fink. Very simple and gives variable expansion and reversibility with one eccentric. Crank and eccentric are opposite. Arm G Q guides eccentric rod and link which is fastened to it at J. Arm N B lifts radius arm to various positions in link. Not a good motion, as steam distribution is very unequal.



Fink Valve Gear.

Fire Kindler.—Usually an oil burner with an air blast for starting fires in locomotives or other fierboxes. Designed to do away with the use of wood in starting fire. They generally use a little oily waste to start with, although with soft coal this is not necessary.

Firebox—Buchanan. A revival of the oft tried water table in another form. Object was to


Buchanan Firebox.

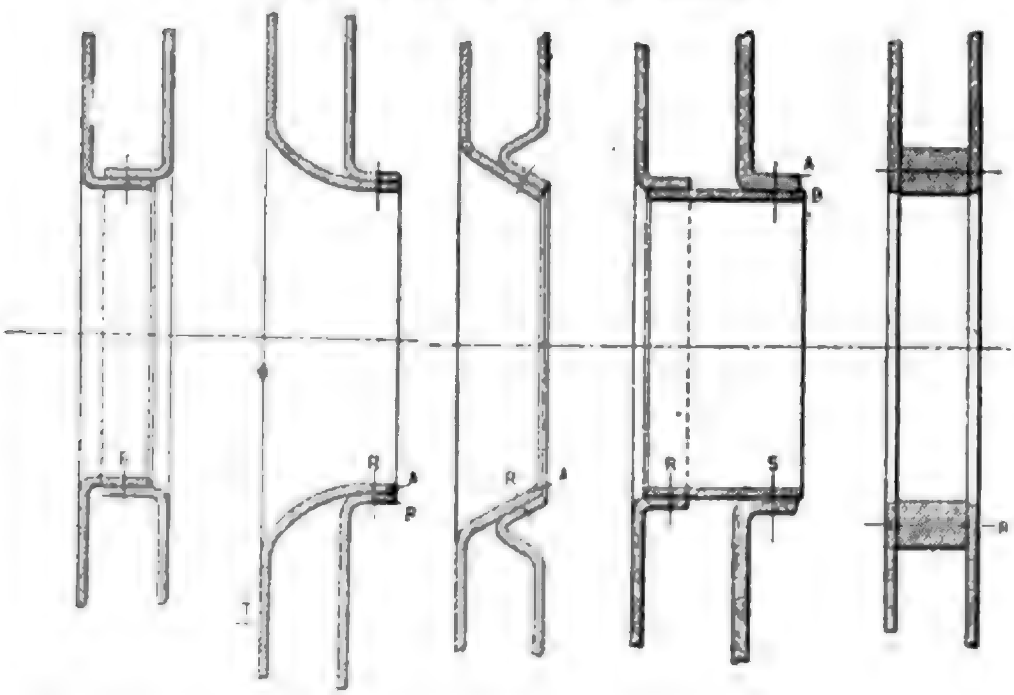
increase heating surface. Not a good box because expensive to make and keep up. And the body of cold water so near fire chilled gases before they ignited.

Fishplates:—Name given to the pieces used in holding rail ends together. Many forms are used, some of which go under rail and form a support for rail.

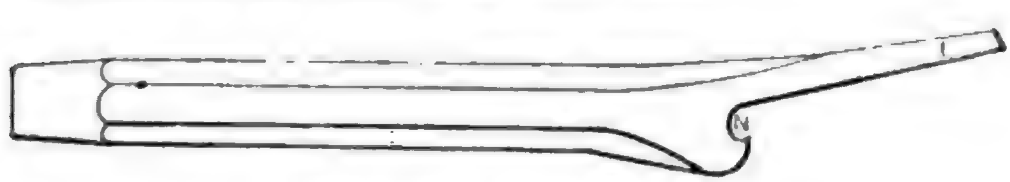
Fire-Depth (Average).—

Bituminous	20 inches
Anthracite	9 inches

Firebox Door Sheets.



Flexible Staybolts.—See Staybolt.



Flue Beading Tool.

Flue Spacing.—There is little doubt that the spacing of flues has received too little attention, the object seeming to be to get in as

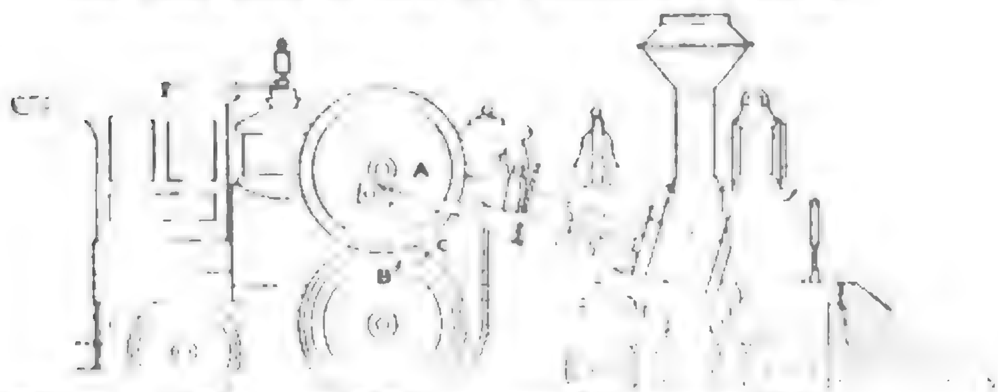
many as possible, and so increase the apparent heating surface. That this is not all effective is shown by tests, and the fact that boilers so crowded do not make steam in proportion to their calculated heating surface. This was brought out by Mr. O. H. Reynolds in his admirable report on boilers before the Master Mechanics' Association in 1903. He quotes D. K. Clark's rule for spacing, which allowed ⅛ of an inch between flues (not centers) for every 30 flues in the boiler. With 210 flues they would be spaced ⅞ of an inch between flues.

Foaming:—Oil, or alkali or other matter makes the water froth like soap suds. This is called foaming. This often makes water show at stack and washes oil from valves and pistons, making them work hard.

Follower Bolts—Bolts that fasten the follower or outside plate to the piston. See cuts of pistons.

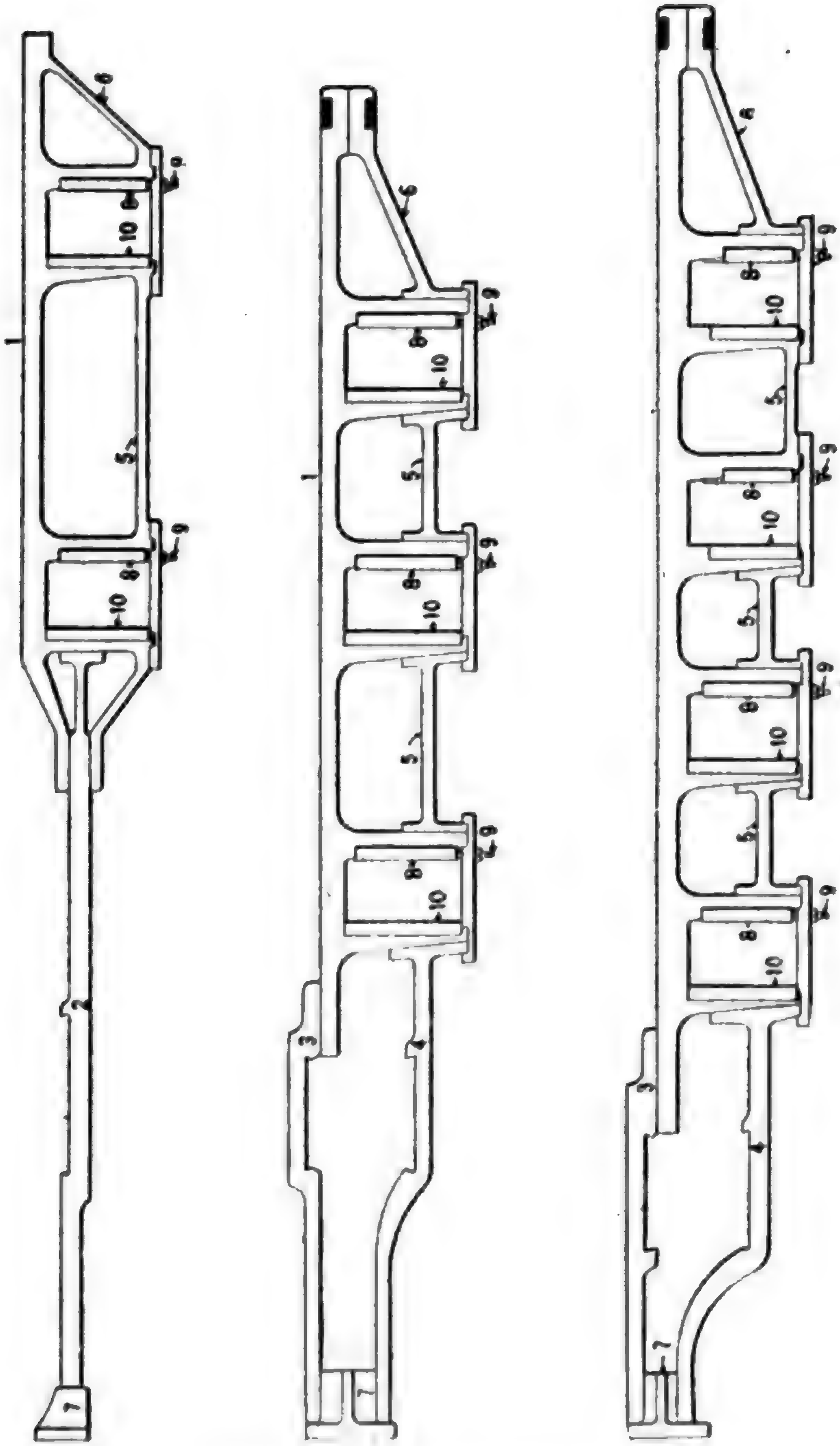
Follower stops. See drawbar stop.

Fontaine Locomotive.—One of the freaks of 1881. Main drivers were mounted on top of drivers on rail and drove by friction of tires.



Fontaine Locomotive.

A—Wheel driven by cylinder.
B—Tire on main driver, driven by A. does not touch rail.
C—Tire on rail.



Frames of Locomotives.

F-5

Fork Motion. Used by R. Stephenson & Co., between 1835 and 1842. Also used in this country before Rogers introduced the "link" on American roads.

Foundation Ring—Another name for mud ring see mud ring.

Frames and Pedestals.—1. Top rails and pedestals. 2. Front rail. 3. Front rail top. 4. Front rail bottom. 5. Middle brace. 6. Back brace. 7. Frame filling piece. 8. Pedestal wedge. 9. Pedestal wedge bolt. 10. Pedestal gib.

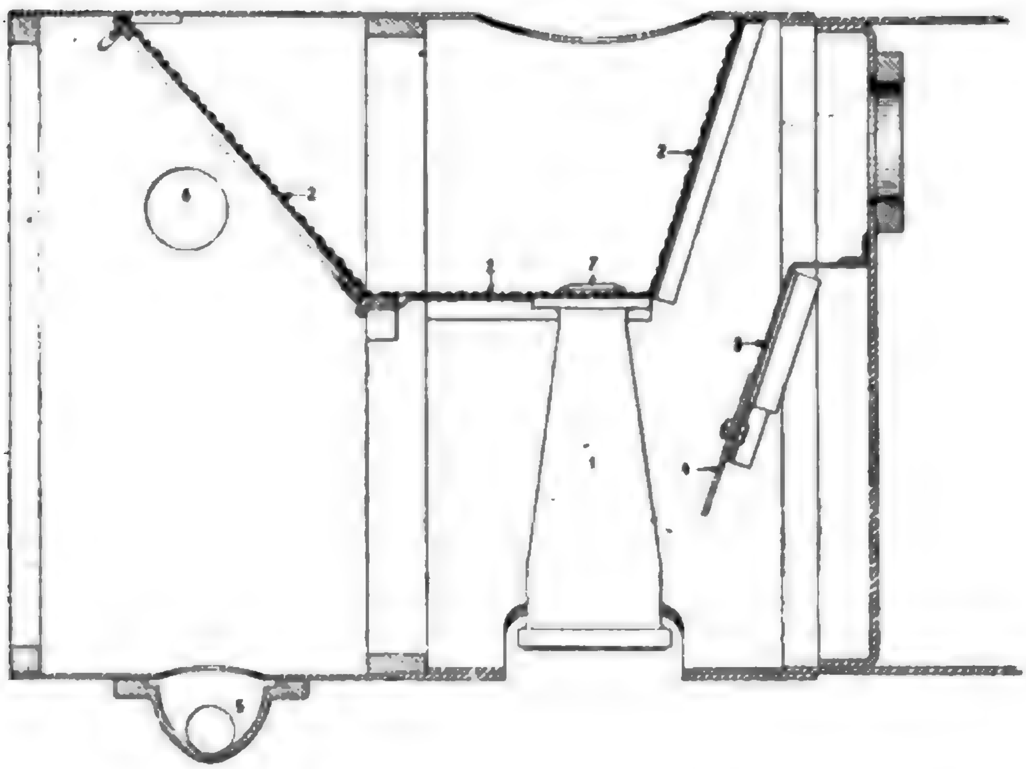
Friction—co-efficient of—The relation between the weight of an object and the power required to move it, or its resistance to motion. If a block of iron weighing 100 pounds requires a pull of 31 pounds to move it, its co-efficient of friction is .31 or 31 per cent. This depends also on the material in contact and the lubrication.

Friction of Brake Shoes.—Varies with speed and brake shoes. With some shoe and wheels the co-efficient is .074 at 60 miles an hour, .241 at 10 miles an hour, .273 at 5 miles an hour, and .33 just as train comes to a stop.

Friction Draft Gear:—A device for absorbing some of the shocks occuring in all trains This is accomplished by having sliding surfaces whose friction absorbs most of the shocks.

Friction of Locomotive: Authorities differ as to average internal friction. Wellington gave 5 to 8 per cent. of indicated power: Forsyth 10 per cent. It varies with the number and condition of bearings, coupled wheels, valves, etc., as well as amount of oil used.

Front End.—The part ahead of the front tube sheet of boiler.



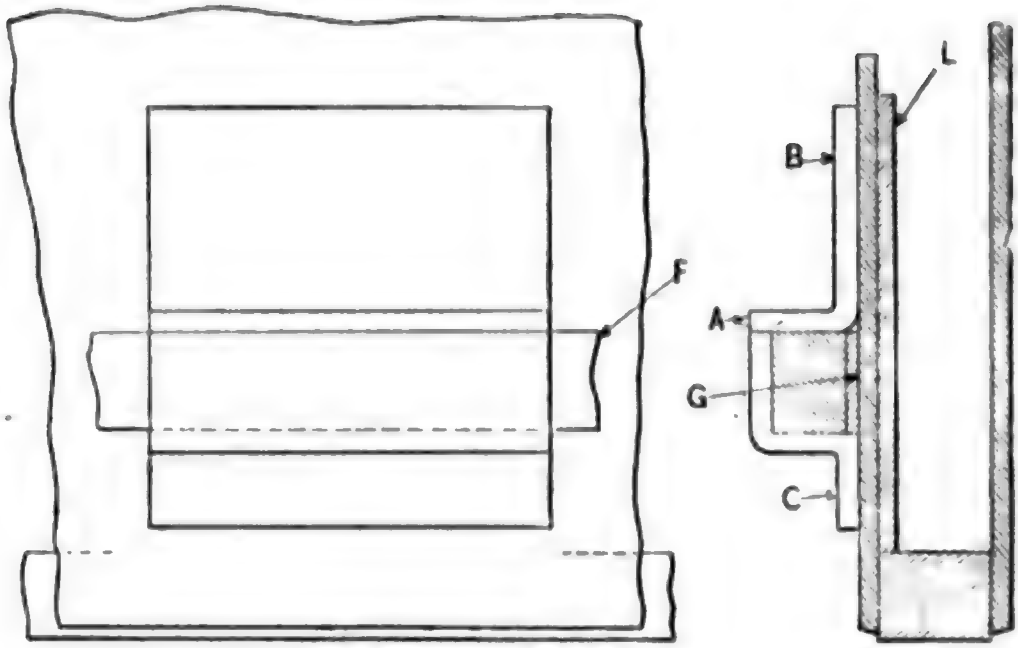
Front End.—1. Exhaust nozzle. 2. Netting. 3. Deflecting plate. 4. Sliding plate for adjustment. 5. Spark ejector. 6. Cleaning hole and cap. 7. Exhaust nozzles, tips or thimbles.

Frost Cock: Practically same as pet cock. To drain water out to prevent freezing.

Fuel.—See Briquettes, coal, oil, etc.

Fulcrum:—The point on which a lever rests in doing its work. This is sometimes a sharp edge, at others a round surface, and sometimes a moving one, as in the case of a claw hammer or spike puller.

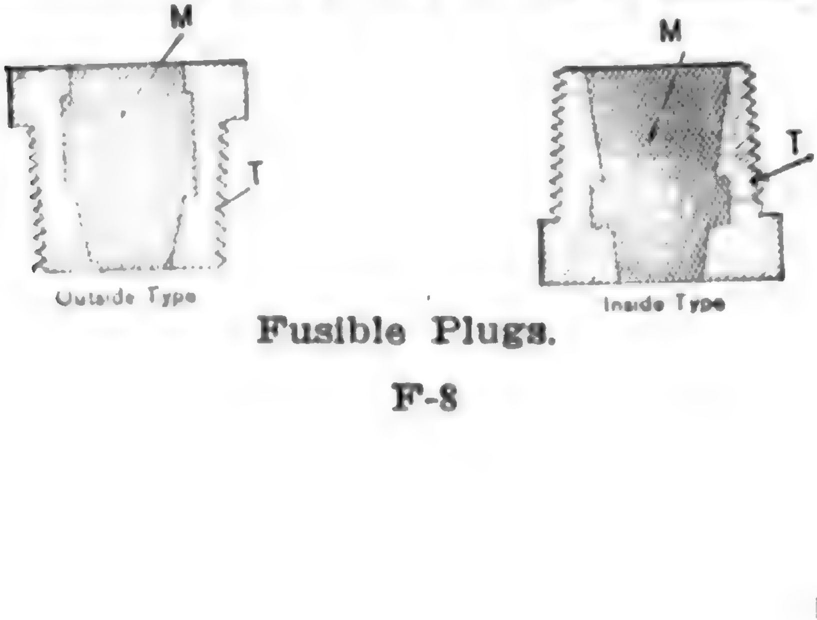
Furnace Bearer.—Method of supporting firebox end of boiler on frames and allowing for longitudinal movement due to expansion.



Furnace Bearer.

<u>Fusee.</u> A slow burning torch which will give light for a given time—three or five minutes. They have a pointed iron base, and when dropped from a train will stick in tie or ground. When found burning they give warning that another train is less than three or five minutes ahead.

<u>Fusible Plug:</u>—A brass plug, screwed into crown sheet at a high point. This has a hole through it which is filled at a metal which fuses at a low temperature, but little above that of the steam carried. When water gets as low as to uncover plug, the fusible metal melts and gives warning. Should be renewed every two or three months.



Fusible Plugs.

G

<u>Gage of Track</u>.—See Track gage.

<u>Gages of Principal Railroads of World</u>.

Algiers—4 ft. 8½ in.—40 in.—3 ft. 6 in.
Argentine—5 ft. 6 in.—4 ft. 8½ in.—metre.
Austria—4 ft. 8½ in.—metre—2 ft. 6 in.
Australia—see South and West Australia.
Belgium—Meter—4 ft. 3 in.
Borneo—Metre.
Brazil—Metre—5 ft. 3 in.
Bulgaria—4 ft. 8½ in.
Barbadoes—2 ft. 6 in.
Canada—4 ft. 8½ in.
Cape of Good Hope—3 ft. 6 in.
Ceylon—5 ft. 6 in.—2 ft. 6 in.
Chili—5 ft. 6 in.—4 ft. 8½ in.—4 ft. 2 in.
China—4 ft. 8½ in.
Columbia—3 ft.
Cuba—4 ft. 8½ in.
Denmark—4 ft. 8½ in.—metre.
Dutch Indies—3 ft. 6 in.
Ecuador—3 ft. 6 in.
Egypt— 4 ft. 8½ in.—3 ft. 6 in.
England—4 ft. 8½ in.
Finland—5 ft.— 2 ft. 5½ in.
France—4 ft. 8½ in. metre— 2 ft. 7½ in.
Germany—4 ft. 8½ in.—metre—29½ in.
Greece—4 ft. 8½ in.—metre.

Guatemala—3 ft.
Holland—4 ft. 8½ in.
Hungary—4 ft. 8½ in.—metre—2 ft. 6 in.
India—5 ft. 6 in.—metre—2 ft. 6 in.
Ireland—5 ft. 6 in.—3 ft.
Italy—4 ft. 8½ in.—metre—3 ft. 2 in.
Japan—3 ft. 6 in.
Jamaica—4 ft. 8½ in.
Mexico—4 ft. 8½ in.—3 ft.
Newfoundland—3 ft. 6 in.
New South Wales—4 ft. 8½ in.
New Zealand—3 ft. 6 in.
Nicaragua—3 ft. 6 in.
Norway—4 ft. 8½ in.—40 in.—29½ in.
Nova Scotia—4 ft. 8½ in.
Paraguay— 5 ft. 6 in.
Panama—5 ft.
Peru—4 ft. 8½ in.— 3 ft.
Porto Rico—4 ft. 8½ in.—3 ft.
Portugal—5 ft. 6 in.—metre.
Queensland—3 ft. 6 in.
Russia—5 ft.
Servia—4 ft. 8½ in.
Scotland—4 ft. 8½ in.
South Australia—5 ft. 3 in.
Spain—5 ft. 6 in.—metre.
Sweden—4 ft. 8½ in.—3 ft. 6 in.—2 ft. 7½ in.
Siberia—5 ft.
Switzerland—4 ft. 8½ in.—metre.
Siam—4 ft. 8½ in.
Tasmania—3 ft. 6 in.
Transvaal— 3 ft. 6 in.
Turkey (in Europe)—4 ft. 8½ in.
Turkey (in Asia)—4 ft. 8½ in.—metre.
United States—4 ft. 8½ in.—4 ft. 9 in.—3 ft.
Uruguay—4 ft. 8½ in.
Venezuela—3 ft. 6 in.—2 ft.
Victoria—5 ft. 3 in.
Western Australia—3 ft. 6 in.

Gage Cocks.—See try cocks.

Galion:— U. S. gallon contains 231 cu. inches. Imperial gallon contains 277.274 cu. inches. U. S. gallon of water weighs 8 1-3 pounds. Imperial gallon of water weighs 10 pounds. Cubic foot of water weighs 62½ pounds, and contains 7½ U. S. gallons.

Gasket:—A piece of copper or other soft metal, or of asbestos, leather, rubber, etc., which is clamped between two surfaces to make a tight joint. In steam chest covers a small groove is cut around, near the edge, and a copper wire of the right shape, is laid in, then cover is clamped down on the wire until it makes a joint. The ends are usually brazed.

Gauntlet:—A point where parallel tracks of a double track are run into each other so as to go through a single track tunnel or over a single track bridge. It involves the use of frogs, but there are no switches. Is not good practice.

Gauntlet Track.

Gib. A piece of metal or other material to take the wear from main piece. Is fastened to either sliding or stationary. Usually tapered and adjustable to take up wear.

Glands:—Bushing to hold the packing against the piston rod or valve rod.

Glass bearings.—Were tried by Grant Locomotive Works but were short lived. Were used on the Highlander, built for the Boston and Providence R. R. in 1850 or 1851.

Gondola:—A name given a type of flat car with low sides.

Grab Iron:—Handle on engine, tender or car to assist getting on or off. Sometimes called "hand holds."

Grades:—Feet per mile. Number of feet rise per mile of track. The English method is to give distance in which it rises 1 foot, such as 1 in 800, 1 in 400, etc., 1 in 100 = 1 per cent. = 52 8-10 feet per mile.

Grades: Per cent. Number of feet rise to every 100 feet of track—measured on the rails.

Grate Area.—Size of firebox grates. Average about 3 sq. ft. to each cubic foot of cyl. volume for bituminuous coal. 4 sq. ft. for antracite, 9 sq. ft. for small coal or "dirt." 1 sq. foot of grate for each 600 lbs. tractive effort. These are approximate. See A. R. M. M. Asso. Proceedings for 1897.

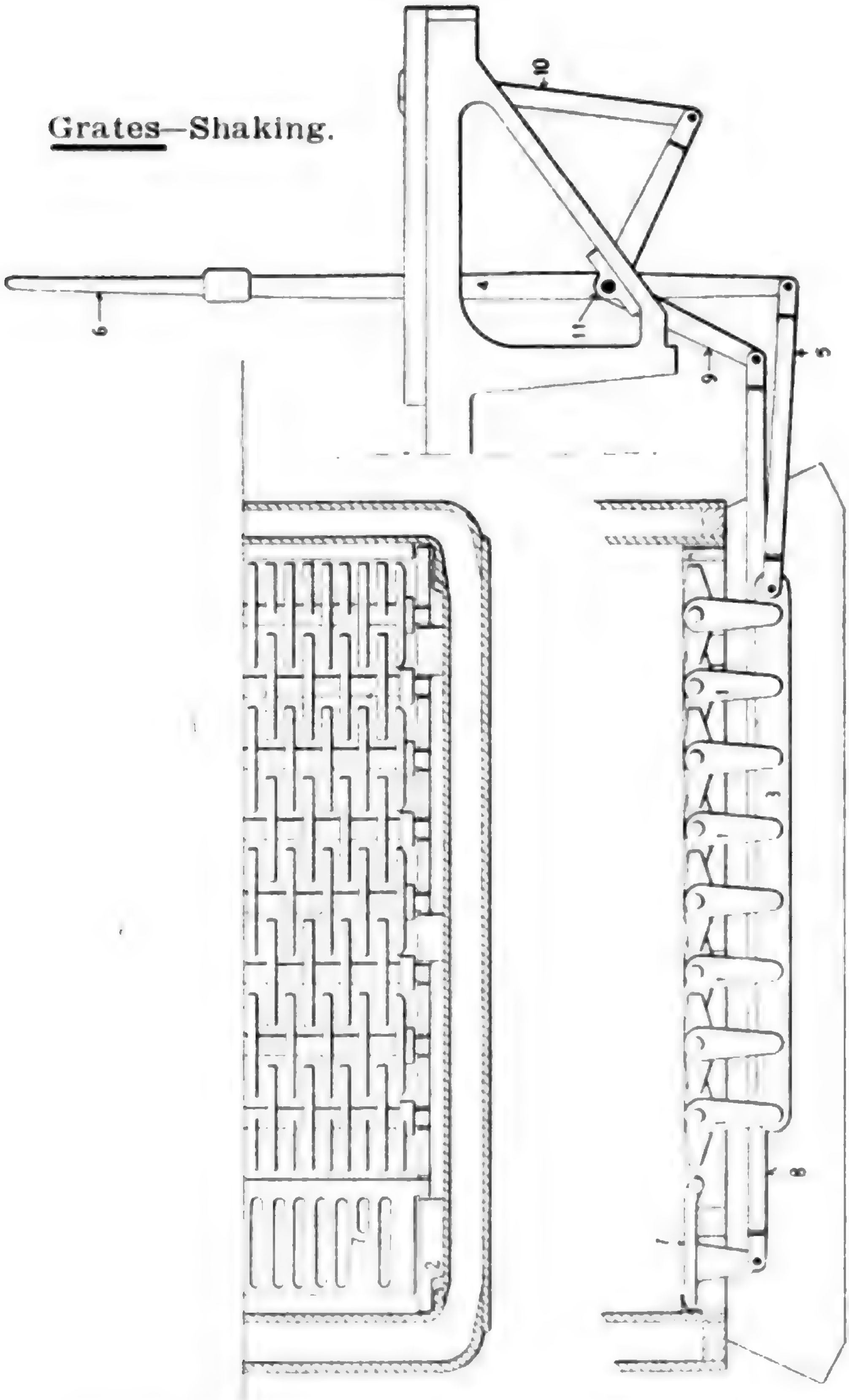
Grate Area.—An experiment conducted in London, by the well known ship builders, Yarrow & Co., has a close bearing on the subject. They tried a 1,200 horse power boiler having 3,217 square feet of heating surface and 53 square feet of grate. With this ratio of 60 to 1, the evaporation per pound of fuel was 9.06 pounds. By cutting the grate down to 40 square feet and increasing the ratio to a little over 80 to 1, the fuel evaporated 10.59 pounds of water to the pound.

Grease Box.—See journal box.

GRADES.				LOADS.	
1	2	3	4	5	6
Per Cent. of Grade.	Rise in Feet, per Mile.	Length of Grade to 1 Foot Rise.	Resistance in Pounds per Ton at 10 Miles per Hour.	Tons Hauled by Average Locomotive for every 1000 lbs. on Drivers.	
.1	5.28	1000.	6.5	38.4	30.8
.5	26.4	200.	14.1	17.7	14.1
1.	52.8	100.	23.6	10.6	8.4
1.5	79.2	66.66	34.7	7.2	5.7
2.	105.6	50.	44.5	5.5	4.4
2.5	132.	40.	54.	4.6	3.6
3.	158.4	33.33	64.9	3.8	3.
3.5	184.8	28.57	74.5	3.3	2.4
4.	211.2	25.	84.3	2.9	2.3
4.5	237.6	22.22	94.7	2.7	2.1
5.	264.	20.	104.6	2.3	1.8
5.5	290.4	18.18	114.7	2.1	1.7
6.	316.8	16.66	124.9	2.	1.6

Column 2 gives feet per mile equivalent to per cent. grade in column 1.
Column 3 shows distance in which grade rises 1 foot.
Column 4 resistance per ton hauled for grade given at 10 miles per hour.
Column 5 the tons that can be hauled at above speed for every 1000 pounds on locomotive drivers. This is based on the assumption that tractive power is one quarter the total weight on drivers, which many use.
Column 6 is same as column 5 except being based on one-fifth weight of drivers and may be safer on that account.

Grates—Shaking.



Grate—Rocking.—1. Bar. 2. Frame. 3. Connecting bar. 4. Lever. 5. Rod. 6. Handle. 7. Drop plate. 8. Rod. 9. Crank. 10. Handle. 11. Bearing.

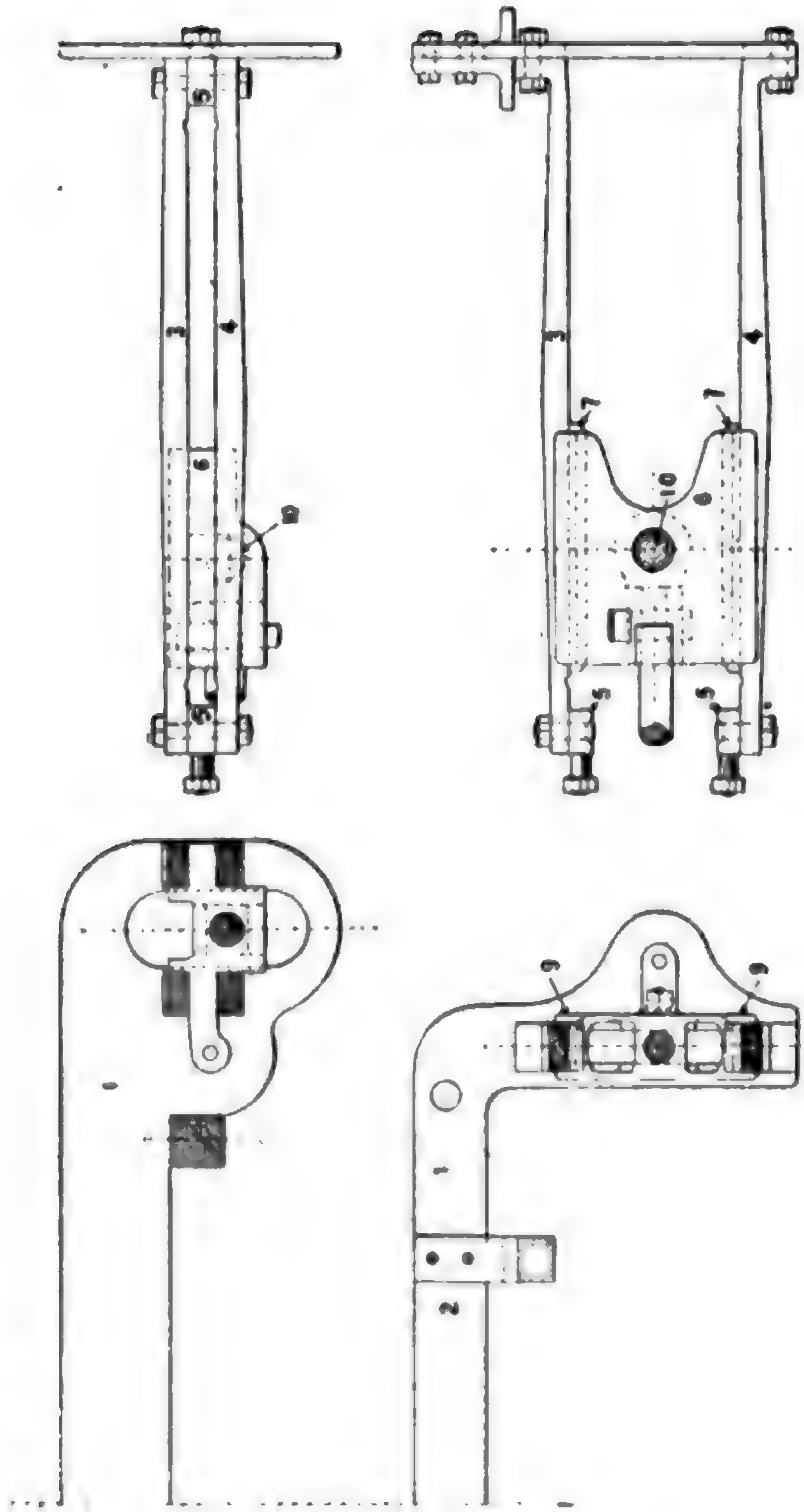
Grease for Crank Pin.—On Mallet compound, B. & O. R. R.—294 miles per pound of crank-pin grease.

Guide bearer. Another name for guide yoke. See guide yoke.

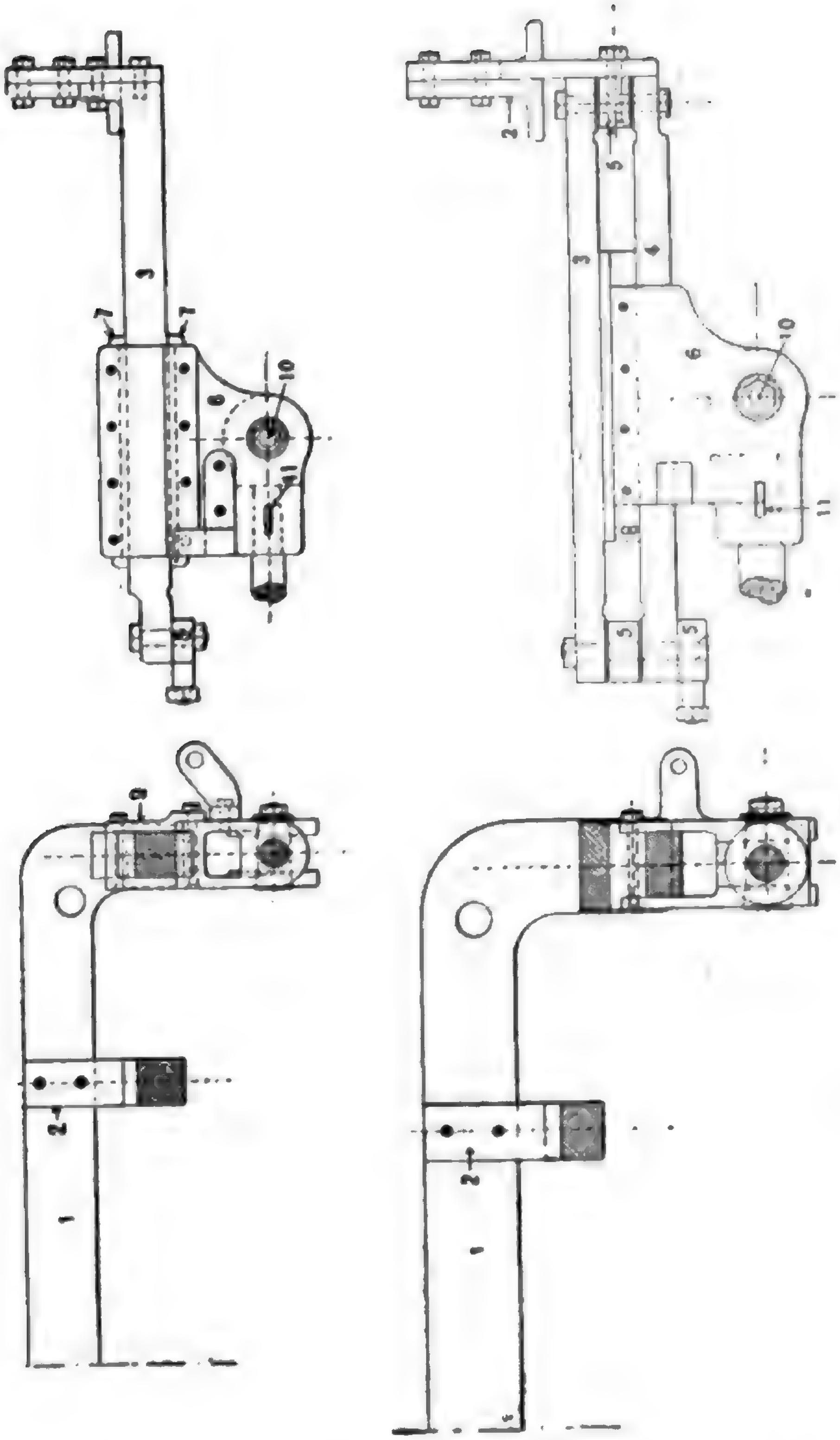
Guard Rail:—An extra rail placed beside the regular rail to prevent wheels going far astray, should car jump the track. Used on curves and on some other bad pieces of track.

Guide Yoke. Support for back end of guides. Assumes various forms but usually similar to figure. Is part of or fastened to a piece extending under boiler to other guide yoke. Yoke is usually closed at bottom to catch main rod and keep it off the ground, should the crank pin break or rod itself be broken.

Guides, Guide Bearers and Crossheads.—1. Guide bearer. 2. Guide bearer knee. 3. Top guide bar. 4. Bottom guide bar. 5. Guide fillings. 6. Crosshead. 7. Crosshead gib. 8. Filling piece. 9. Plate. 10. Pin. 11. Key.



Crossheads, Guides and Guide Yokes.



Crossheads, Guides and Guide Yokes.

H

Half Crank. See Return Crank.

Hauling Capacity. See Tractive Power.

Head Block.—See dead wood.

Headlights—Cost of. Oil at 7⅝ cts. per gallon tank car lots) 33-100 cts. per hour. Acetyline.—Carbide at 3¼ cts (ton lots) 58-100 cts. per hour.

Headlight.—See also Acetylene.

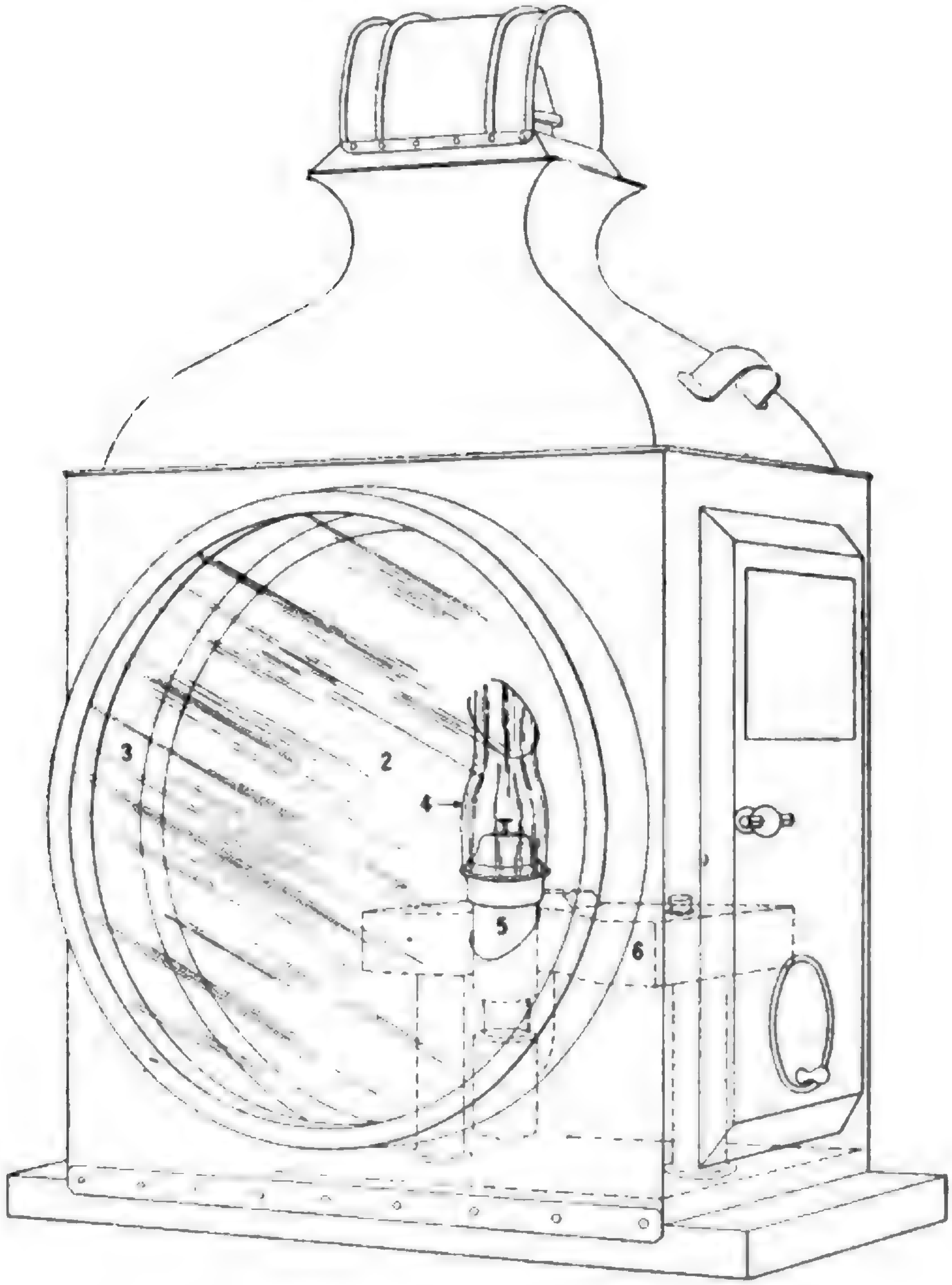
Heat producing power of coal and oil.—See Petroleum.

Heating Shops.—See Shops.

Heating surface.—Those parts of a locomotive boiler which have heat on one side of the metal and water on the other—tubes, crown and side sheets—flue sheets. All heating surface is not equally effective, depending on its location in the boiler and its distance from the fire.

Heating surface—Proportions of. One sq. ft. to 10 lbs. tractive power. 180 sq. ft. heating surface to 1 cubic ft. of cyl. volume for large anthracite coal. 200 sq. ft. h. s. to 1 cu. ft. cyl volume for small antracite or bituminous coal Fire box heating surface should be 10 per cent. of total. Also 40 to 60 sq. ft. of hs. to 1 sq. ft. of grate. See A. R. M. M. Assoc. for 1897.

Headlight.—1. Case. 2. Reflector. 3. Glass. 4. Chimney. 5. Burner. 6. Reservoir.



Heat Unit.—Heat required to raise one pound of water one degree. Taken at the greatest density of water from 39.1 to 40.1 degrees Fahr.

HEATING SURFACE OF FLUES, IN SQUARE FEET.

Outside Diameter in Inches	Length, Feet. 1	2	3	4	5	6	7	8	9	10	11	12
1½	.3927	.7854	1.178	1.570	1.963	2.356	2.748	3.141	3.534	3.92	4.319	4.712
1¾	.4582	.9163	1.374	1.832	2.291	2.748	3.207	3.665	4.123	4.581	5.039	5.497
2	.5236	1.047	1.571	2.094	2.618	3.141	3.665	4.183	4.712	5.236	5.759	6.283
2¼	.5891	1.178	1.767	2.356	2.945	3.534	4.123	4.712	5.301	5.89	6.479	7.068
2½	.6545	1.309	1.963	2.618	3.272	3.927	4.581	5.236	5.89	6.545	7.199	7.854

Outside Diameter in Inches	Length, Feet. 13	14	15	16	17	18	19	20	21	22	23	24
1½	5.105	5.497	5.890	6.283	6.675	7.068	7.461	7.854	8.246	8.639	9.032	9.424
1¾	5.956	6.414	6.872	7.330	7.788	8.246	8.705	9.163	9.621	10.080	10.537	10.996
2	6.806	7.330	7.854	8.377	8.901	9.424	9.948	10.472	10.995	11.519	12.043	12.566
2¼	7.657	8.246	8.835	9.424	10.014	10.603	11.192	11.781	12.370	12.959	13.548	14.137
2½	8.508	9.163	9.817	10.472	11.126	11.781	12.435	13.090	13.744	14.398	15.053	15.708

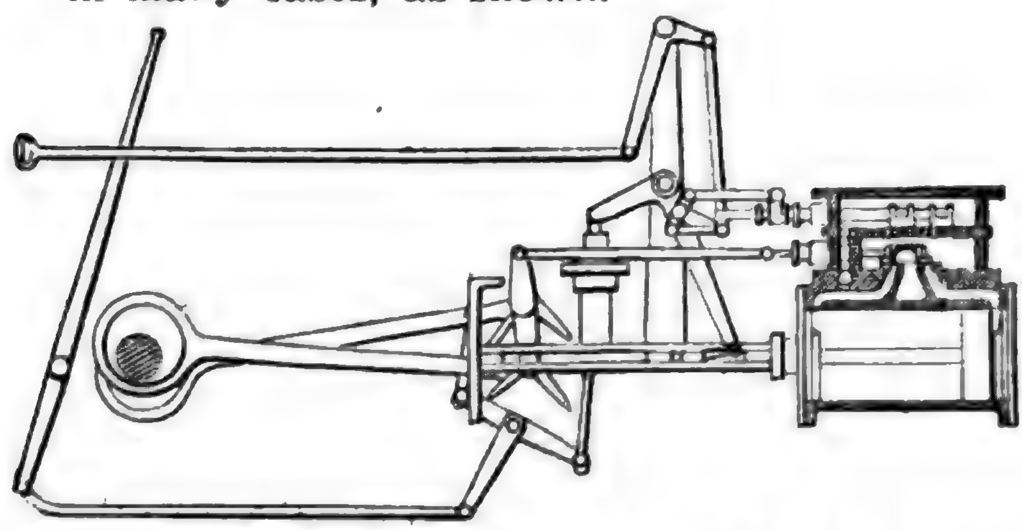
Heating Surface Per Horse Power.—

	Sq. Ft.
Vertical	15 to 20
Locomotive	12 to 16
Horizontal return tube	15
Water tube	10 to 12
Flue	8 to 12
Plain cylinder	6 to 10

With the intense draft used in locomotive practice a horse power is sometimes produced for three square feet of heating surface.

Hollow staybolt.—See staybolt.

Hook Motion.—The fore-runner of the link motion. Gave a reversing motion, but no variation of cut-off. Separate cut-off valve used in many cases, as shown.



Rogers' V Hooks, Motion with Cut off.

Horse Power Constant.—This may be for any given engine at a fixed speed, and in this case is "area of piston, × length of stroke in feet, × strokes per minute÷33,000." This multiplied by mean effective pressure used at any time gives horse power. It may be for some engine at varying speeds. Then it is area of piston × stroke in feet÷33,000. This multiplied by M. E. P. and strokes per minute =H. P. Or it may be simply for a given cylinder diameter, when it becomes "area of piston ÷33,000." This multiplied by M. E. P. and piston speed=H. P.

Horse Power of Locomotives.—Not a good way of reckoning the power of a locomotive as it depends on the speed, which varies. Rule is

multiply area of one piston in square inches by mean effective pressure, by twice length of stroke in feet, by revolutions of drivers per minute and divide by 33,000. Example—Engine 20×24 inches, 200 pounds of steam, drivers 60 inches, 25 miles an hour. Area= 314.16 times 4 feet times 170 (see mean effective pressure) times 140 divided by 33,000=323 horse power at this speed. Or, having tractive power, multiply by miles per hour and divide by 375.

Horse Power-hour.—One horse power developed continuously for one hour.

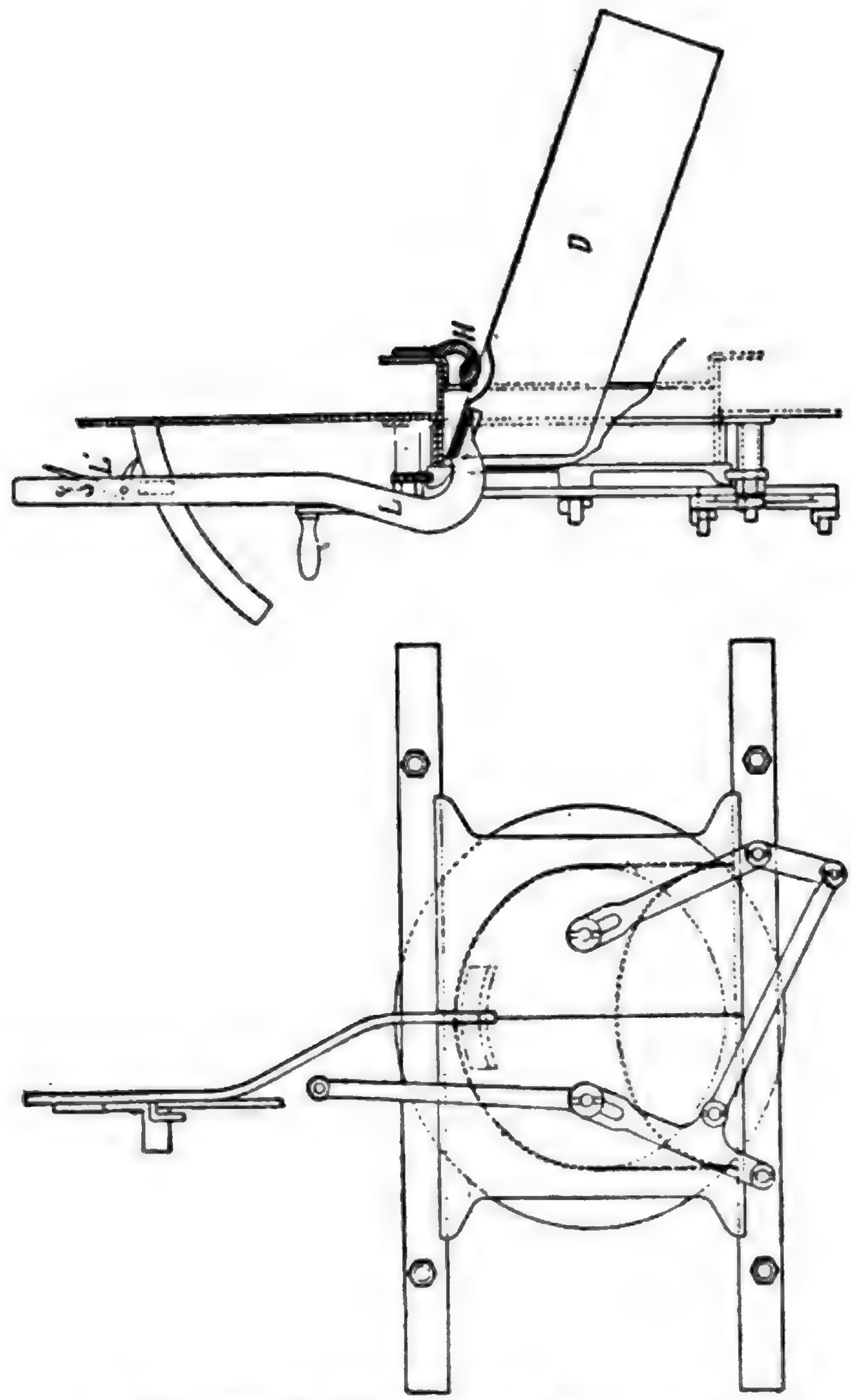
Housing Box.—See journal box.

Hump Yard.—A yard or terminal with a high place or hump, from which cars descend by gravity to desired track.

Hydraulic Ram.—A simple devise for raising water when there is a large volume of waet at low head. Where there is a good supply of water and a fall of 18 inches or more, the hydraulic ram is often used for pumping to the water tank. This works by the sudden stoppage of flow of water using the momentum to force a portion of it in any desired direction.

A rough and ready rule is: One-seventh of the water used can be raised five times as high as the fall and so on in this proportion. This does not hold for piping over 100 feet long .

With a fall of 10 feet it will raise 1 gallon 50 feet high for every 7 gallons used, or with a 5 foot fall will raise — gallon 50 feet high for every 14 gallons used.



Hudson's Fire Door Deflector.

<u>Hudsons Fire Door Deflector.</u> Devised by Wm. S. Hudson, Supt. of Rogers Locomotive Works in 1865, to force air entering fire door down on to hot coals so it would be heated before striking flues. Used inside a sliding door as shown.

I

Igniting temperature:—Gases given off by coal ignites at about 1800 deg. Fahr. Maximum temperature of heat in firebox is from 2000 to 2500 deg. Fahr. Appearance of fire at different temperatures is given as follows:

1300	deg.	Fahr—	Dull red.
1650	"	"	Full cherry red.
1830	"	"	Bright red.
2200	"	"	Bright orange.
2370	"	"	White heat.
2550	"	"	Welding heat.

Inches of Mercury.—Used in connection with vacuum produced by condensers; 2.04 inches of mercury equals one pound pressure per square inch; 29.9 inches of mercury equal atmospheric pressure of 14.7 pounds.

Inches of Water.—Used in connection with chimney draft. 27.6 inches of water equal one pound pressure. 1.72 inches equal one ounce pressure. One foot (12 inches) of water equals .434 pounds per square inch.

Indicators.—Indicator calculations are easily understood. The steam forces the piston up, the distance depending on the spring used,

and the mark of the pencil shows the steam pressure in the cylinder at the different points of the stroke.

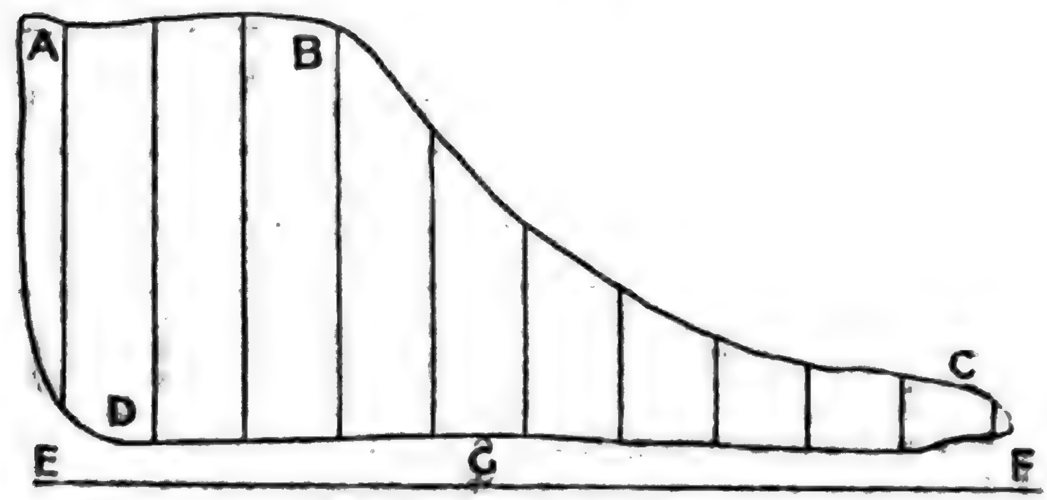
Divide the diagram into any number of equal parts, say ten, and measure the height of each line as shown. Add these together and divide by the number of lines. This will be the average forward pressure from which deduct the back pressure. The difference is the mean effective pressure.

If you have a planimeter for measuring the diagram, it is easier as well as more accurate. The regular planimeter gives the area of the card or diagram in square inches. Divide this by the length of the diagram in inches, which will give the average height. This multiplied by the spring used gives the pressure on every square inch of the piston. Springs are numbered according to the pressure required to compress them enough to move the pencil one inch vertically. An 80 spring will show 1½ inches in height on the diagram for 120 pounds pressure. A diagram taken with a 60 spring will be two inches high at the same pressure, and so on. As multiplying the average height by the spring used gives the m. e. p. on each square inch of piston, then multiplying this by the area of piston and by piston speed and dividing the whole by 33,000 gives horse power.

Indicator:—An instrument having a piston which is usually half a square inch in area and which carries a spring on top of it. The under side is connected to the cylinder by a pipe so that the same pressure exists in both places. With a 100 pound spring the indicator pencil will be raised 1 inch for every 100 pounds of steam or half an inch with

50 pounds. As the pressure falls the pencil drops and the diagram it makes shows the varying pressure of steam in the cylinder. See Indicator Card or Diagram.

Indicator Card or Diagram: A diagram drawn by the indicator which shows the action of steam in the cylinder. The points of a card are as shown in drawing.



Indicator Card.

A—Admission, B—Cut-off, C—Exhaust opens, D—Compression, E F—Atmospheric line, G—Back pressure.

Industrial Railways:—Small railways, nearly always narrow gage, running around a yard or in shops or both. Very often have flange outside of rail instead of inside as on regular railways.

Injector:—An instrument invented by Henri Gifford of France in 1858, which uses a jet of steam to force water into a boiler, usually the one supplying the steam. Although a seeming impossibility, it will force against a higher pressure than the steam used.

INERTIA OF TRAINS.—I.

S Speed Miles per Hour to be Attained in given Distance	Tractive Force, Pounds per Ton (2000 Pounds), to Attain Speed S, in Distance D from Starting Point, $= 66.86 \frac{S^2}{D}$									
	100 Feet	250 Feet.	500 Feet.	750 Feet.	1,000 Feet	1,500 Feet.	2,000 Feet.	3,000 Feet.	4,000 Feet.	5,000 Feet.
4	10.69	4.28	2.14	1.42	1.07	.713	.535	.356	.267	.214
5	16.7	6.68	3.34	2.22	1.67	1.11	.835	.556	.417	.334
6	24.	9.6	4.8	3.2	2.4	1.6	1.2	.803	.603	.481
8	42.7	17.1	8.54	5.7	4.27	2.84	2.13	1.42	1.07	.854
10	66.8	26.7	13.35	8.91	6.68	4.45	3.34	2.22	1.67	1.33
12	96.	38.4	19.2	12.8	9.6	6.4	4.8	3.21	2.41	1.92
15	150.	60.	30.	20.	15.	10.	7.5	5.01	3.75	3.
20	267.	106.	53.4	35.6	26.7	17.8	13.35	8.9	6.67	5.34
25		166.	83.4	55.6	41.7	22.8	20.85	11.4	10.42	8.34
30		240.	120.	80.2	60.1	40.1	30.	20.	15.04	12.03
35		326.	163.	108.	81.8	54.3	40.9	27.1	20.4	16.36
40		......	214.	142.	107.	71.3	53.5	35.6	26.7	21.4
45			270.	180.	135.	90.	67.6	45.	33.8	27.
50		......	334.	222.	167.	111.	83.5	55.6	41.7	33.4
55		......	404.	269.	202.	134.	101.	67.	55.5	40.4
60		......	......	320.	240.	160.	120.	80.3	60.3	48.1
65	......	......	......	376.	282.	188.	141.	94.	70.5	56.4
70	......	......	......	......	327.	218.	163.	109.	81.5	65.4

Inertia.—The tendency of a body at rest to resist motion and a body in motion to continue moving.

INERTIA OF TRAINS.—II.

S Speed Miles per Hour to be Attained in given Time.	Tractive Force, Pounds per Ton (2000 Pounds) to Attain Speed S, in Time t from Starting $= 1.52 \frac{S}{t}$									
	½ Minute.	1 Minute.	1½ Minute.	2 Minutes.	3 Minutes.	4 Minutes.	5 Minutes.	6 Minutes.	8 Minutes.	10 Minutes.
4	12.16	6.08	4.08	3.04	2.02	1.52	1.21	1.01	.76	.60
5	15.2	7.6	5.06	3.8	2.53	1.9	1.52	1.26	.95	.76
6	18.24	9.12	6.12	4.56	3.03	2.28	1.81	1.51	1.14	.9
8	24.32	12.16	8.16	6.08	4.04	3.04	2.42	2.02	1.52	1.2
10	30.4	15.2	10.12	7.6	5.05	3.8	3.04	2.52	1.9	1.52
12	36.48	18.24	12.24	9.12	6.06	4.56	3.63	3.03	2.28	1.82
15	45.6	22.8	15.2	11.4	7.6	5.7	4.6	3.8	2.85	2.28
20	60.8	30.4	20.24	15.2	10.12	7.6	6.08	5.04	3.8	3.04
25	76.	38.	25.3	19.	12.65	9.5	7.6	6.3	4.75	3.8
30	91.2	45.6	30.4	20.2	15.2	11.4	9.2	7.6	5.7	4.56
35	106.	53.2	35.4	24.	17.7	13.3	10.7	8.86	6.65	5.32
40	121.	60.8	40.8	30.4	20.2	15.2	12.16	10.08	7.6	6.08
45	136.	68.4	45.8	34.2	22.7	17.1	13.68	11.34	8.55	6.84
50	152.	76.	50.6	38.	25.3	19.	15.2	12.6	9.5	7.6
55	167.	83.6	55.6	41.8	27.8	20.9	16.7	13.86	10.45	8.36
60	182.	91.	60.	40.	30.	23.	18.4	15.2	11.4	9.12
65	197.	98.6	65.	44.	32.5	25.	20.	16.4	12.4	10.
70	212.	106.	70.	47.8	35.	26.9	21.28	17.66	13.35	10.7

Injector—Capacity. Water that should be delivered.

Gage	Pressure	10, 29	lbs.	per lb.	of steam.
"	"	20, 25	"	"	"
"	"	40, 23	"	"	"
"	"	70, 17.6	"	"	"
"	"	100, 16.6	"	"	"
"	"	120, 14.7	"	"	"
"	"	150, 10.9	"	"	"
"	"	200, 8.8	"	"	"

Injector—Lifting. One provided with a lifting jet for raising water to instrument so as to be forced into boiler by forcing tubes. Capacity decreases with hight of lift—chance for trouble increases. Theoretical limit is 34 feet; practical limit is about 26 feet.

Injector—Non-lifting. One in which the water flows to it—not a lifter.

Injector: Restarting: Lifting injector so arranged that if its water supply is interrupted it will start to work as soon as water is again obtainable. Designed especially for yachts and traction engine, where suction pipe is apt to be out of water at times.

Injectors.—The importance of these instruments is not appreciated till a failure holds up the fast mail or other important train. They work so steadily that we often forget the work they do or the steam they use. Some of the larger ones can throw 5000 gallons per hour or over 83 gallons per minute. As a gallon weights 8 1-3 pounds this means 684 pounds per minute.

As it takes from 60 to 85 pounds of steam per minute to force this into the boiler, this

power being kept from the cylinders, the injector uses more steam than we think. A fair average may be taken as 10 to 12 per cent. of the power of the engine. With one of the large engines this may amount to 125 horse power and is much more than is usually supposed.

Careful handling of the injector will do more to make a good steaming engine and to save fuel than is generally supposed. If an injector takes 10 per cent. of the steam, shutting it off before climbing a bad grade adds this to the power of the engine. To do this it is necessary to know the road so as to fill the boiler before the hill is reached. When the hard pull is over, the water is low enough to start the injector again and keep the "pops" from blowing. Or the injector may be used at half its capacity, reducing the steam used and heating the water much hotter before entering the boiler so that it requires less heat to become steam.

In the same way feeding a boiler at stations is often a good plan, in spite of the old prejudice against it, as it keeps the safety valve from popping. By shutting off the injector just before starting the full power is available and the fire can be fixed as desired before more water is needed.

Injector, range of working. One manufacturer gives the following data for stationary injectors—they are probably maximum under best conditions:

With cold feed water:

When lifting 5 feet, works at steam pressures from 15 to 240 pounds.

When lifting 10 feet, works at steam pressures from 20 to 200 pounds.

When lifting 15 feet, works at steam pressures from 25 to 170 pounds.

When lifting 20 feet, works at steam pressures from 35 to 110 pounds.

When lifting 25 feet, works at steam pressures from 45 to 90 pounds.

When feed water at 100 Fahrenheit.

When lifting 5 feet, works at steam pressures from 15 to 180 pounds.

When lifting 25 feet, works at steam pressures from 45 to 90 pounds.

With feed water at 100 degrees Fahrenheit:

When lifting 5 feet, works at steam pressures from 15 to 190 pounds.

When lifting 10 feet, works at steam pressures from 30 to 150 pounds.

When lifting 15 feet, works at steam pressures from 40 to 130 pounds.

When lifting 20 feet, works at steam prespressures from 45 to 90 pounds.

When lifting 25 feet, works at steam pressures from 50 to 75 pounds.

Steam pressures required for various lifts:

With a lift of 5 feet, 15 pounds steam pressure is required.

With a lift of 10 feet, 20 pounds steam pressure is required.

With a lift of 15 feet, 25 pounds steam pressure is required.

With a lift of 20 feet, 35 pounds steam pressure is required.

With a lift of 25 feet, 45 pounds steam pressure is required.

—"Hancock" catalog.

Injector—Velocity of Steam and Water. Velocity of steam jet 2900 to 3400 feet per second. Velocity of water 186 to 346 feet per second.

Injectors:—Water and steam used.

	Size	Weight of water per lb. of steam
Belfield	10	9.69
Garfield	7	13.53
Little Giant	7	12.92
Mack	7	13.79
Metropolitan	9	13.16
Monitor	9	11.31
Sellers, 1887	8½	13.80

Iron Driving Box.—See driving box—Grand Trunk R. R.

Intercepting Valve.—Valve used in compound locomotives to "intercept" the steam and make engine either simple or compound at will. Some work automatically by receiver pressure, others entirely in control of engineer.

Interlocking:—The movement of one part being dependent on another or locking with it. As applied to signals it means that the switch cannot be moved without the signal showing its position. Or two switches may be interlocked so one may not be moved without other.

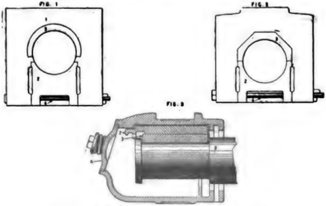
Isothermal Expansion.—The expansion of equal temperature in which the pressure and volume vary inversely. In other words, one increases as the other decreases. Doubling the volume halves the pressure, etc.

J

Jaw Block.—See draft timber.

Joints.—See Fish plates. Number of joints per mile of single track. Length of rails 20 feet, 528; 24 feet, 440, 30 feet, 352; 45 feet, 264; 60 feet, 176.

Journal bearing. The metal bearing which support the car on the axle. Also called journal brass and axle bearing.



Journal Boxes.—(See next page).

Journal box. Box enclosing the end of axle and bearing. Made of cast iron or cast steel and showing dust tight cover.

Journal Boxes.—Fig. 1.—Driving Box. Fig. 2.—Truck Box.

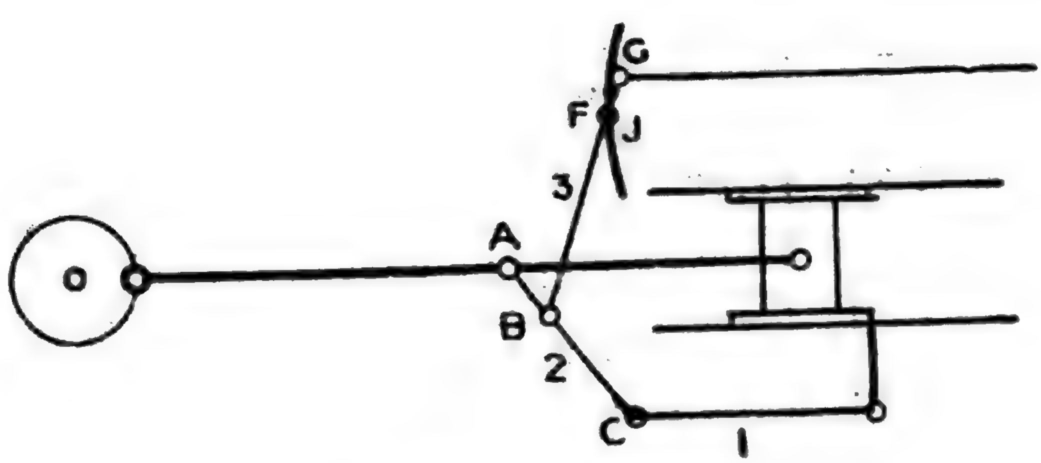
1. Box. 2. Cellar. 3. Brass. 4. Cellar bolt.

Fig. 3.—Tender Box.

1. Box. 2. Wedge. 3. Brass. 4. Lid. 5. Axle.

Journal brass.—See journal bearing.

Joy Radial Valve Motion.—A motion devised by Joy of England, and used to some extent on locomotives in that country. The valve motion comes entirely from connecting rod. Lead is constant



Joy Valve Gear.

A—Connection on main rod, B—Connection on arm 2 to link block F, J—Link, G—Valve stem block.

BEARING PRESSURE FOR LOCOMOTIVE JOURNALS.

Based on Pressure of 180 Pounds per Square Inch of Projected Area. These Figures show the Safe Allowance for Driving and Trailing Journals of Passenger Locomotives.

Diameter of Journal	LENGTH OF JOURNAL.														
	2"	3"	4"	5"	6"	7"	8"	9"	10"	11"	12"	13"	14"	15"	16"
2"	720	1080	1440	1800	2160										
2¼"	810	1215	1620	2025	2430										
2½"	900	1350	1800	2250	2700										
2¾"	990	1485	1980	2475	2920										
3		1620	2160	2700	3240										
3¼		1755	2340	2925	3510										
3½		1890	2520	3150	3780	4410	5040								
3¾			2700	3375	4050	4725	5400								
4			2880	3600	4320	5040	5760	6480							
4¼			3060	3825	4590	5355	6120	6885							
4½			3240	4050	4860	5670	6480	7290	8100						
4¾			3420	4275	5130	5985	6840	7695	8550						
5				4500	5400	6300	7200	8100	9000	9900	10800				
5½					5940	6930	7920	8910	9900	10890	11880				
6						7560	8640	9720	10800	11880	12960				
6½						8190	9360	10530	11700	12870	14040				
7						8820	10800	11340	12600	13860	15120				
7½						9450	10800	12150	13500	14850	16200				
8							11520	12960	14400	15840	17280				
8½							12240	13770	15300	16830	18360				
9							12960	14580	16200	17820	19440				
9½"								15390	17100	18810	20520	22230			
10"									18000	19800	21600	23400	25200	27000	28800
10½"									18900	20790	22680	24570	26460	28350	30240
11"									19800	21780	23760	25740	27720	29700	31680

BEARING PRESSURES FOR LOCOMOTIVE JOURNALS.

Based on Pressure of 200 Pounds per Square Inch of Projected Area. These Figures show the Safe Allowance for Driving, Engine Truck and Trailing Journals of Freight Locomotives and Switching Locomotives.

Diameter of Journal.	LENGTH OF JOURNAL.														
	2"	3"	4"	5"	6"	7"	8"	9"	10"	11"	12"	13"	14"	15"	16"
2	800	1200	1600	2000											
2¼	900	1350	1800	2250											
2½	1000	1500	2000	2500	3000										
2¾	1100	1650	2200	2750	3300										
3		1800	2400	3000	3600	4200									
3¼		1950	2600	3250	3900	4550									
3½		2100	2800	3500	4200	4900	5600								
3¾			3000	3750	4500	5250	6000								
4			3200	4000	4800	5600	6400	7200							
4¼			3400	4250	5100	5950	6800	7650							
4½			3600	4500	5400	6300	7200	8100	9000						
4¾			3800	4750	5700	6650	7600	8550	9500						
5				5000	6000	7000	8000	9000	10000	11000	12000	13000	14000	15000	16000
5½				5500	6600	7700	8800	9900	11000	12100	13200	14300	15400	16500	17600
6					7200	8400	9600	10800	12000	13200	14400	15600	16800	18000	19200
6½					7800	9100	10400	11700	13000	14300	15600	16900	18200	19500	20800
7						9800	11200	12600	14000	15400	16800	18200	19600	21000	22400
7½						10500	12000	13500	15000	16500	18000	19500	21000	22500	24000
8							12800	14400	16000	17600	19200	20800	22400	24000	25600
8½							13600	15300	17000	18700	20400	22100	23800	25500	27200
9								16200	18000	19800	21600	23400	25200	27000	28800
9½								17100	19000	20900	22800	24700	26600	28500	30400
10									20000	22000	24000	26000	28000	30000	32000
10½									21000	23100	25200	27300	29400	31500	33600
11									22000	24200	26400	28600	30800	33000	35200

BEARING PRESSURE FOR LOCOMOTIVE JOURNALS.

Based on Pressure of 300 Pounds per Square Inch of Projected Area. These Figures show Safe Allowance for Tender Journals.

Diameter of Journal.	Length of Journal.														
	2"	3"	4"	5"	6"	7"	8"	9"	10"	11"	12"	13"	14"	15"	16"
2"	1200	1800	2400	3000	3600										
2¼"	1350	2025	2700	3375	4050										
2½"	1500	2250	3000	3750	4500										
2¾"	1660	2475	3300	4125	4950										
3"		2700	3600	4500	5400										
3¼"		2925	3900	4875	5850										
3½"		3150	4200	5250	6300	7350	8400								
3¾"			4500	5625	6750	7875	9000								
4"			4800	6000	7200	8400	9600								
4¼"			5100	6375	7650	8925	10200	11475	12750						
4½"			5400	6750	8100	9450	10800	12150	13500						
4¾"			5700	7125	8550	9975	11400	12825	14250						
5"				7500	9000	10500	12000	13500	15000	16500	18000				
5½"				8250	9900	11550	13200	14850	16500	18150	19800				
6"					10800	12600	14400	16200	18000	19800	21600				
6½"					11700	13650	15600	17650	19500	21450	23400				
7"						14700	16800	18900	21000	23100	25200	27300	29400		
7½"						15750	18000	20250	22500	24750	27000	29250	31500		
8"							19200	21600	24000	26400	28800	31200	33600		
8½"							20400	22950	25500	28050	30600	33150	35700		
9"							21600	24300	27000	29700	32400	35100	37800		
9½"								25650	28500	31350	34200	37050	39900		
10"									30000	33000	36000	39000	42000	45000	48000
10½"									31500	34650	37800	40950	44100	47250	50400
11"										36300	39600	42900	46200	49500	52800

K

Key Way.—Channel or groove cut in shaft to hold a key. Usually cut to about equal depth in both shaft and hole of piece which goes on it, as axle and eccentric.

Kilowatt—Electrical term meaning "1000 watts." (Watt=1 ampere × 1 volt). 746 watts equal one mechanical horse power, so that a kilowatt equals 1.34 horse power.

King Bolt.—See center pin.

Knee timber.—See draft timber.

L

Lap Express:—A method used on some suburban roads by which trains make alternate stops. Train 1 will stop at 1st, 3rd, 5th, etc., stations, and train 2 stops at 2d, 4th, 6th, etc. It facilitates handling trains at short intervals.

Lap.—See valves. Lead.—See valves.

Latch: The piece which engages the teeth or notches of a quadrant, either on the reverse lever or throttle.

Latent Heat.—The heat required to separate the molecules or particles of water when forming it into steam. At atmospheric pressure this is 965.7 heat units.

Lead.—Lead increases when the straps turn on the eccentrics against or opposite the movement of crank (or when the link moves opposite from the crank in hooking up.

Lead decreases when the straps turn on the eccentrics with the movement of the crank or when the link moves with the crank in hooking up.

Variation of lead depends on the length of eccentric rods and the distance between link pins. Shorter rods increase lead more

than long rods with pins same distance apart.

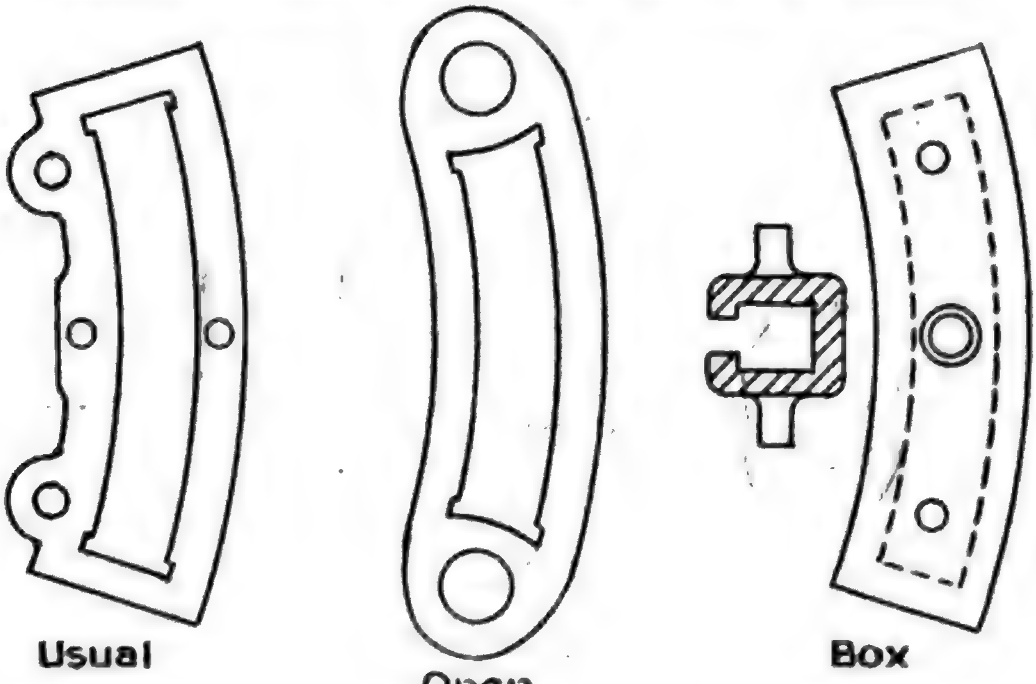
Increasing distance between link pins increases variation in lead between full stroke and center notch.

Le Chatelier Brake.—See Water Brake.

Length of Link:—Extreme length of opening measured in a straight line from the center or link arc.

Leverage.—See Brake Leverage.

Lifting Shaft:—Sometimes called "tumbling shaft" though "reversing shaft" would seem a better name. The shaft carrying arms from which links are suspended by link hanger and to which the "reach" or reversing" rod is connecting. Usually extends across under boiler from frame to frame.



Links.—Several forms are made, those generally used in this country being constructed as shown—regular-open and box. See valve gears.

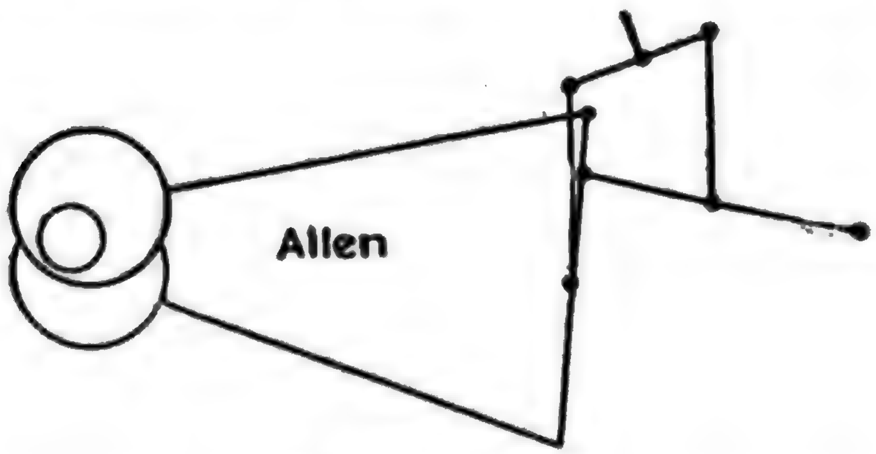
Link Arc:—Radius of center of link.

Link Block. Block sliding in link and driving rocker arm or valve rod direct. Made in one, two or three pieces according to link in which it is used.

Link Block Pin. Pin running or working in link block, and driving rocker arm (where one is used) or valve rod direct. Generally about same diameter as valve rod pin.

Link Motions. Various devices embodying a link which have been used to move valve. Most prominent are the Williams erroneously called the Stepenson or Howe) Allan, Joy, Gooch, Fink, Walschaeret, Waldegg, Strong, and Lewis. See Valve Motions.

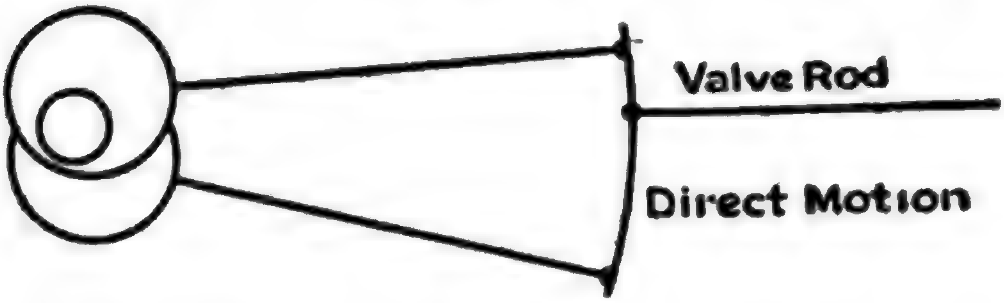
Link Motion—Allen. A link motion having a straight instead of curved link. Both the link and block are shifted, and in oposite directions as shown. The lead varies but not as much as the shifting link (Williams).



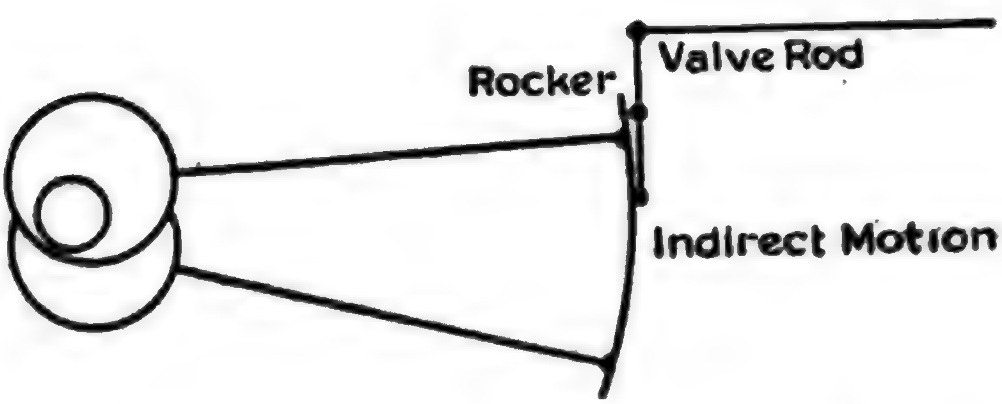
Allen Link Motion.

Link Motion. Crossed Rods: An unfortunate term given to link motion with eccentric set opposite from usual manner, so that rods are crossed when they are usually

open. The effect is to have ports covered when reverse lever is in center, instead of having "lead" as usual. Good for switch engines as throttle leaking cannot start engine with reverse lever in center.



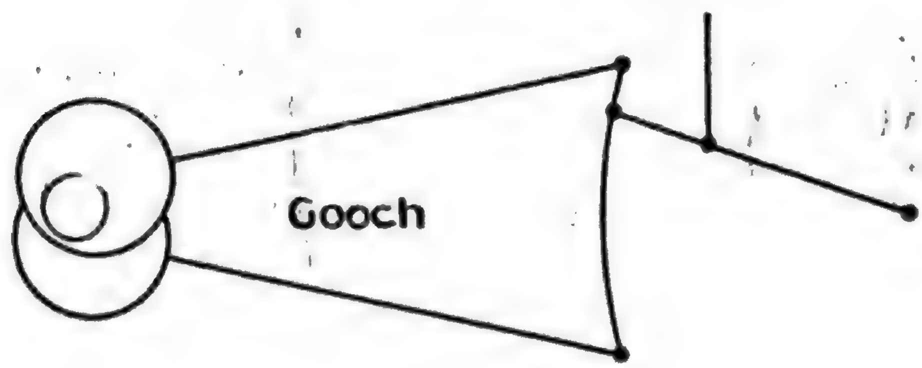
Link Motion—Direct. Motion of eccentric transmitted direct to valve rod or with transmission bar which does not reverse the motion. See cut.



Link Motion—Indirect. Where motion due to eccentric is reversed by a rocker arm as shown.

Link Motion—Open Link. A peculiar form of link used to some extent in British practice. The rods couple at ends so that eccentrics must have larger throw than valve has travel at extreme end. They are usually hung from upper eccentric rod pin and have reverse shaft below central line of motion.

Link Motion—Stationary Link. Valve motion in which link is suspended from a fixed point. Reversal and cut-off is secured by a radius rod moving the link block in the link. See cut of Gooch link motion.



Link Saddle. Piece on link by which it is connected to link hanger. Usually placed at center of link.

Link Saddle Pin or Stud. Pin in link saddle which connects to link hanger. On box links these pins are directly on the outside of links, no saddle being necessary. Is located back of link arc on open links.

Locomotives.—Life of. The average annual mileage on the Midland Railway (England) is about 20,000, and for the Northwestern (England) 16,000 miles. The average cost of repairs on one road 5.28 cents per mile, and on the other 5 cents per mile. The average mileage life for brass tubes was 82,400, and for copper tubes 122,500 miles. The average for boilers is 382,000; cylinders, 319,700, and for crank axles, 191,500 miles. In comparison with these figures the average annual mileage of locomotives on American roads,

is estimated at 40,000 miles, and the average cost of repairs, about 4 cents per mile, and in connection with the question of cost, the higher wages paid for labor in the United States counts in favor of the American locomotive. The wearing qualities of the American boiler outlasts 400,000 and of cylinders 450,000 miles.

Locomotive—Coal Consumption:—DeGlehn Compound, Northern Railway of France, 1500 H—Weight 65 tons—train 370 tons, 184 miles, Paris to Calais in 3 hours and 10 minutes—1 stop—on 38½ pounds of coal per mile. Another weighing 80 tons, 1900 H., 350 tons behind tender. Steam per H. P., 24 lbs. Boiler evaporates 7.7 lbs. of water per lb. of coal. Mr. Charles R. King, in Railway Engineer, April, 1904, gives test of 0-6-4 engines on Adriatic Railway, Italy, in which a horse power hour is secured for 1.97 lbs. coal. It is one of the new type with cab and firebox in front.

Locomotive—Cross Compound.—High pressure on one side, low on the other. Also called two-cylinder compound. Built by Baldwin, Pittsburg, Rhode Island, Richmond and Schenectady. Have reducing valve to equalize power on each side when running simple and an intercepting valve to throw into simple or compound as desired. Some do this automatically, some only when engineer desires.

Locomotive—Power required to move.—See Friction of locomotive.

Lookout—See cupola.

Locomotive—Length of. Varies but about as follows:

Engine Wheel Base—

Consolidation	26 ft.	
Ten wheel	25 ft.	8 in.
Pacific	33 ft.	
Atlantic	27 ft.	6 in.
Eight wheel	24 ft.	3 in.

Total Wheel Base—Engine and tender—

Consolidation	59 ft.	9 in.
Ten wheel	57 ft.	2 in.
Pacific	62 ft.	2 in.
Atlantic	58 ft.	8 in.
Eight wheel	50 ft.	

Total length over all—

Consolidation	69 ft.	10 in.
Ten wheel	67 ft.	4 in.
Pacific	71 ft.	8 in.
Atlantic	68 ft.	8 in.
Eight wheel	60 ft.	

Locomotive repairs. Average of 43,871 locomotives gives cost of one locomotive per year for repairs $2343. On another road the cost was reduced to $1646.

This cost is gradually being lowered by the increasing use of modern machine tools and improved shop facilities. The record made on Niles 90 inch. Driving Wheel Chucking Lathe in December, 1905, 10 prs. driving wheel tires finished in 9 hrs., 6 mins., was on October 10, 1906, lowered on the same machine to 10 prs. finished in 8 hrs., 15 mins.

Locomotives in service, June 30, 1903, in United States. Report of Interstate Commerce Commission gives Passenger, 10,570; freight, 25,444; switch, 7,058; others, 799, total 43,871.

Locomotive Tandem—Compound.—Cylinders arranged one behind the other with same piston rod.

Locomotives.—Weight of parts. Santa Fe type (2-10-2) 1903.

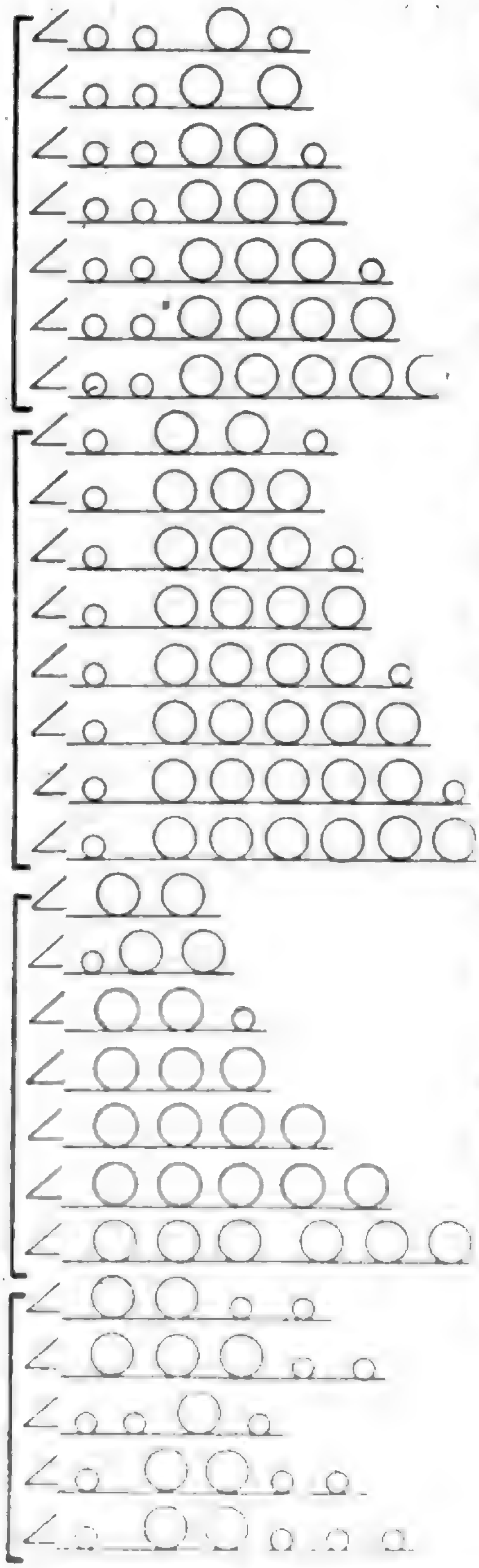
	Lbs.
Driving wheels and axles, main pair..	9,375
Driving wheels and axles, others	8,000
Driving box, main	512
Engine trucks, no wheels, axles or boxes	4,500
Engine truck wheels—1 pair and axle..	2,800
Frames, each	8,400
Boiler shell—no tubes	43,000
Cab—steel	2,690
Axle—main driving	1,875
Crosshead	431
Piston and rod	1,075
Main rods, each	1,030
Side rods, for each side	1,370
Cylinders for one side, no saddle.......	10,160
Saddle	7,100

Baldwin compound 19 and 32 inch cylinders.

Lubricator.—A device for feeding oil to cylinder of engine. Consists of an oil reservoir and a chamber in which steam condenses. Water so formed displaces oil and forces it out of lubricator to cylinder. Some lubricators are positive feed and pump a small quantity each stroke.

Lubricator.—First "up drop" introduced in 1876; double sight feed in 1886, and triple sight feed in 1888.

Locomotives.—Types of.—



Full Truck or Bogie Class.	Single Driver......	4—2—2
	American..........	4—4—0
	Atlantic............	4—4—2
	Ten Wheel.........	4—6—0
	Pacific or St. Paul.	4—6—2
	Twelve Wheel.....	4—8—0
	Mastodon	4—10—0
Pony or Two Wheel Trunk Class.	Columbia..........	2—4—2
	Mogul..............	2—6—0
	Prairie....... ...	2—6—2
	Consolidation......	2—8—0
	Mikado or Calumet	2—8—2
	Decapod............	2—10—0
	Santa Fe...........	2—10—2
	Centipede..........	2—12—0
Switcher Class.	Four Wheels.......	0—4—0
	Four Coupled......	2—4—0
	" "	0—4—2
	Six "	0—6—0
	Eight "	0—8—0
	Ten "	0—10—0
	Articulated—Two six coupled.	
Forney Class.	Forney—Original..	0—4—4
	" 6 coupled	0—6—4
	" Single....	4—2—2
	" Mogul....	2—4—4
	" Suburbs.	2—4—6

Locomotive Classification.

M

Masonry.—All constructions of stone or kindred substitute materials in which the separate pieces are either placed together, with or without cementing material to join them, or where not separately placed are encased in a matrix of firmly cementing material. Rip-rapping and paving are not masonry construction.

Masonry Terms:

Arch Masonry.—That portion of the masonry in the arch ring only, or between the intrados and the extrados.

Ashlar.—A squared or cut block of stone with rectangular dimensions.

Ashlar or Range Masonry.—A collection of ashlar blocks built up in a masonry structure with parallel beds and continuous joints, herein described as first-class masonry.

Backing.—That portion of a masonry wall or structure built in the rear of the visible face. It may be attached to the face and bonded with it or with a space between for filling. It is usually of a cheaper grade of masonry than the face.

Batter.—The slope or inclination of the face.

Bed.—Stone, brick or other building material in position, upon which other material is to be laid.

Beton.—See Concrete.

Block Rubble.—Large blocks of building stone as they come from the quarry. See Rubble.

Bond.—The mechanical disposition of stone, brick or other building blocks by overlapping to break joints.

Brick.—No. 1 hard burned, absorption 2 per cent; No. 2 softer and lighter than No. 1, absorption 5 to 6 per cent.

Broken Ashlar.—Ashlar masonry in which the beds are parallel but not continuous, herein classified as second-class masonry; also sometimes termed broken range masonry.

Cement.—A preparation of calcined clay and limestone, possessing the property of hardening into a solid mass when moistened with water. This property is exercised under water as in open air. Cements are divided into three classes: Portland, natural and puzzolan. See each.

Centering.—A temporary support used in arch construction. Also called Centers.

Concrete.—A compact mass of broken stone or gravel assembled together with cement mortar and allowed to set.

Coping.—A top course of dimension stone or concrete slightly projecting to shelter the masonry from the weather, or to distribute the pressure from exterior loading.

Course.—Each separate layer in stone, concrete or brick masonry.

Dimension Stone.—Blocks of stone cut to specified dimensions.

Dressing.—The finish given to stone or to concrete facing.

Dry Wall.—A masonry wall in which stones are built up without the use of mortar, herein classified as fourth-class masonry.

Face.—The exposed surface in elevation.

Facing.—In concrete: 1st. A rich mortar placed on the exposed surfaces to make a smooth finish.
2d. Shovel facing is working the mortar of concrete to the face.

Flush.—When two or more separate pieces of a structure are laid with their faces or beds in the same plane.

Footing.—A projecting bottom course.

Forms.—Framed construction for holding concrete in desired shape until the final set is attained.

Foundation.—That portion of a structure usually below the surface which distributes the pressure upon the bed.

Grout.—A thin mortar either poured or applied with a brush.

Joint.—A space in masonry construction to be filled with mortar, or remaining unfilled to allow for temperature changes.

Lagging.—Horizontal strips used to carry and distribute the weight of an arch to the ribs or centering during its construction.

Mortar.—A mixture of sand, cement and water, used to cement together the various stones or brick in masonry work.

Natural Cement.—A product formed of calcinated limestone containing clay and carbonate of magnesia, reduced to a fine powder. It possesses the property of hardening either in air or under water when mixed into a paste.

Paving.—Regularly placed stone or brick forming a floor.

Pointing.—Filling joints or defects in the face of masonry structure.

Portland Cement.—A product of the mixture of clay and limestone in definite proportions, calcinated at a high temperature and afterwards reduced to a fine powder. It possesses the quality of hardening either in air or under water when mixed into a paste.

Puzzolan.—An intimate mixture of ground furnace slag and slaked lime without further calcination, which possesses the hydraulic qualities of cement.

Quarry Face or Rock Face.—Stone faced as it comes from the quarry.

Mastodon.—Locomotive with a full (4 wheel) truck and 8 coupled drivers. See Locomotive Types.

Mariotte's law.—Mariotte and Boyle both discovered that with a perfect gas the pressure dropped just in proportion to expansion. That is, if cut off takes place at ¼ stroke with steam at 200 pounds, it will expand to four times the volume and to 50 pounds pressure if a perfect gas. Steam is not.

Mean Effective Pressure.—The "mean" or average pressure forcing piston against the resistance offered in moving train less the

back pressure which it meets. This is pressure which is effective in doing work. See tables of "Constants for Average Pressure."

Mechanical Equivalent of Heat.—The number of foot pounds of mechanical energy contained in one heat unit, as these are convertible. The accepted equivalent is that a heat unit equals 778 foot pounds, or 778 pounds falling one foot will generate one heat unit.

Mileage of Freight Cars.—An average of 5,000 cars gave 9,243 miles as yearly mileage.

Mogul.—Locomotive having a pony (2 wheel) truck and six coupled drivers. First built in 1861. See Locomotive Types.

Mud Drum.—A wrought iron or steel cylinder below boiler. As there is little circulation the mud and scale collects here and is blown out or cleaned, instead of being burned on to the main shell. Is not always favored on account of weakening shell at connections and possibly of giving out itself.

Muffler.—Device for muffling or deadening the escape of steam or air. Used largely on pop safety valves. Also used to some extent to soften noise of exhaust in stations. Various means are employed to accomplish this result.

N

Narrow Gage.—Anything less than 4 feet 8½ inches (or 56½ inches) which is the "standard." There are regular roads, (small but in actual service), which have only 18-inch gage. A common gage is 36 inches for small roads and 39.375 inches (one meter) in foreign countries.

Notches.—Refers to notches cut in quadrants for holding reverse lever in any desired position. Sometimes refer to throttle quadrant.

O

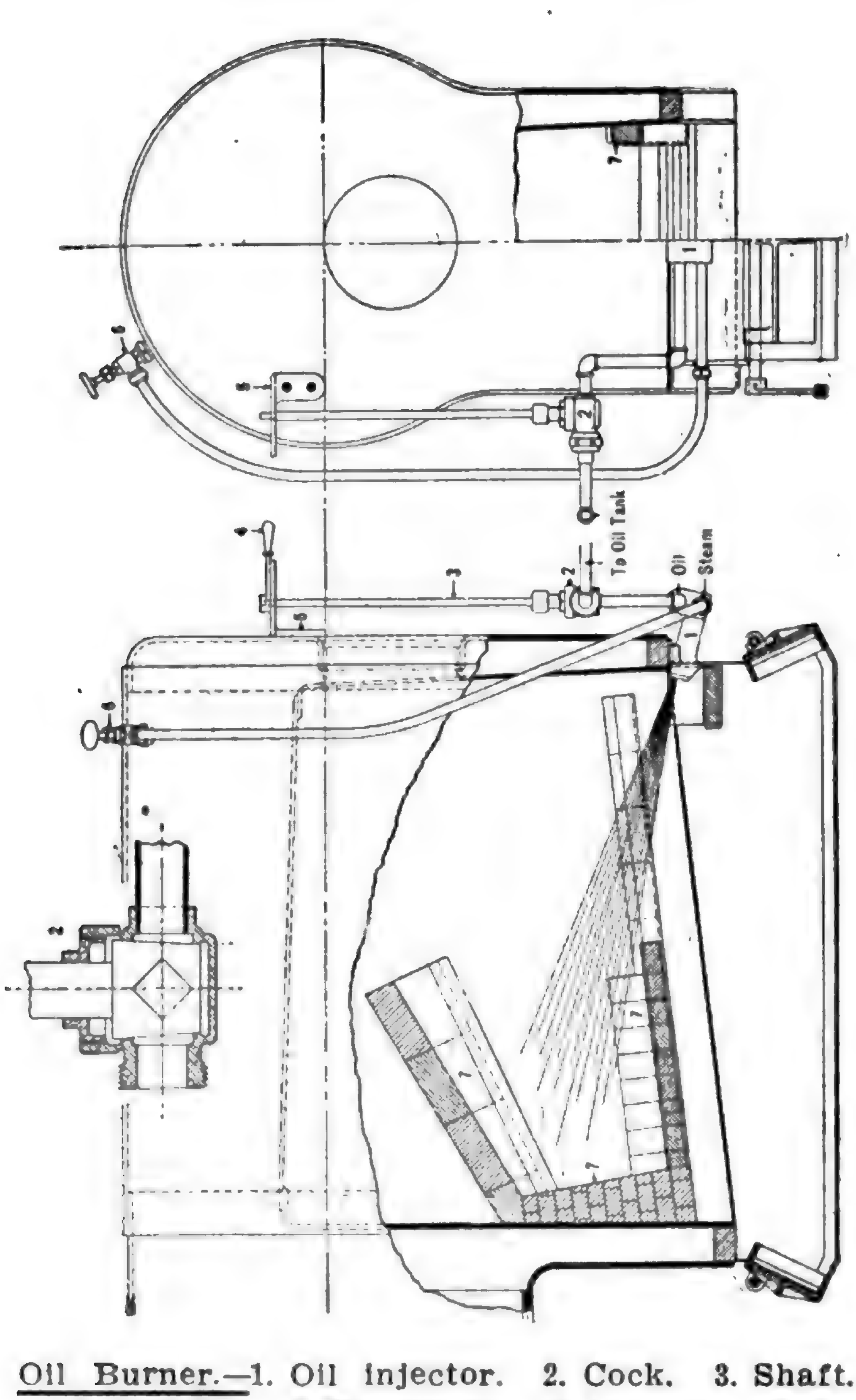
Oil Box.—See Journal Box.

Oil Burner.—Name applied to any locomotive using oil as fuel. Also applied to the device in which the oil is mixed for burning. These mix air and oil or steam and oil and spray it into firebox against the flame or hot fire brick. Usually allow 1-3 inch width of burner per cubic foot of cylinder volume. This usually figures out about one inch width for 600 square feet of heating surface. Evaporation is about 12½ pounds of water per pound of oil from and at 212 degrees.

Oil Consumption.—Engine oil—Mallet compound on B. & O. R. R.—145 miles per pint. Valve oil—200 miles per pint. Crank-pin grease—294 miles per pound.

Oil Cup.—Cup or recess for holding oil to feed to some moving surface. Rod cup for main and connecting rods. Guide cups for guides, etc. Different methods of feed are used from gravity to capillary attraction of some fabric.

Oil.—Drops to a pint. Good valve oil is considered to average 6,600 drops to the pint.



Oil Burner.—1. Oil injector. 2. Cock. 3. Shaft. 4. Handle. 5. Quadrant. 6. Injector steam valve. 7. Fire brick.

Oil: Petroleum.—Experiments with oil of 34 deg. gravity, 140 deg. flash, and 190 degrees fire test. Boiler 27 sq. ft. of grate, 2135 sq. ft. heating, burned 39 pounds of oil per sq. ft. of grate, or 45 pounds per sq. ft. of heating surface. This secured an equivalent evaporation of 12½ pounds of water per pound of oil.

Relative Heating Value of Coal and Oil.

	Pounds of Oil.	Pounds of Coal.
Theoretical Anthracite	1	1.61
Theoretical Bituminous	1	1.37
Urquharts Experiments	1	1.756
Peninsular Car Company....	1	1.742
Elevated Railroad, New York	1	1.785

$$\text{Equivalent price of Coal per Ton} = \frac{2000 \times \text{price of oil per barrel}}{\text{Wt. of oil per gal.} \times \text{gals. per bbl} \times \text{ratio oil to coal.}}$$

$$\text{Equivalent price of Oil per Bbl.} = \frac{\text{Wt. of oil per gal.} \times \text{gals. per bbl.} \times \text{ratio oil to coal} \times \text{price of coal per ton.}}{2000}$$

Relative value of coal and oil.

Fuel alone considered.		All accounts considered	
Oil pr. bbl.	Coal pr. ton.	Oil pr. bbl.	Coal pr. ton.
$ .20	$ .75	$ .20	$ .65
.40	1.49	.40	1.30
.60	2.24	.60	1.96
.80	2.98	.80	2.61
1.00	3.73	1.00	3.26
1.20	4.47	1.20	3.91
1.40	5.22	1.40	4.56
1.60	1.97	1.60	5.22
1.80	6.71	1.80	5.87
2.00	7.45	2.00	6.52

Oil: Petroleum—Crude

Pound.	U. S. Gallon.	Barrel.	Ton (2240 lbs.)
1.	.13158	.0031328	.0004464
7.6	1.	.02381	.003393
319.2	42.	1.	.1425
2240.	294.72	7.017	1.

Taking a ton of coal as 2000 pounds and a barrel of fuel oil at 310 pounds with a heating value of 20,000 B. T. U. per pound, the following table shows their relative values

Coal B. T. U. per lb.	1 lb. oil = lbs. coal.	1 lb. oil = lbs. coal.	1 ton coal = bbls. oil.
10,000	2,000	620	3.23
11,000	1,818	564	3.55
12,000	1,667	517	3.87
13,000	1,538	477	4.19
14,000	1,429	443	4.52
15,000	1,333	413	4.84

This shows that as 1 ton of coal with 13,000 B. T. U. equals 4.19 bbls. of oil, the oil must be obtained at $1 per bbl. to equal the coal at $4.19 per ton.

Oiling Roadbed.—Costs about $100 a mile—2,000 gallons per mile. Takes three hours to mile.

Over-pass.—See By Pass.

P

Pedestal.—The jaws of a locomotive or truck frame in which the driving box or other journal bearing is held.

Pedestal Binder.—Piece for clamping the bottom of pedestal jaws to prevent spreading under strain.

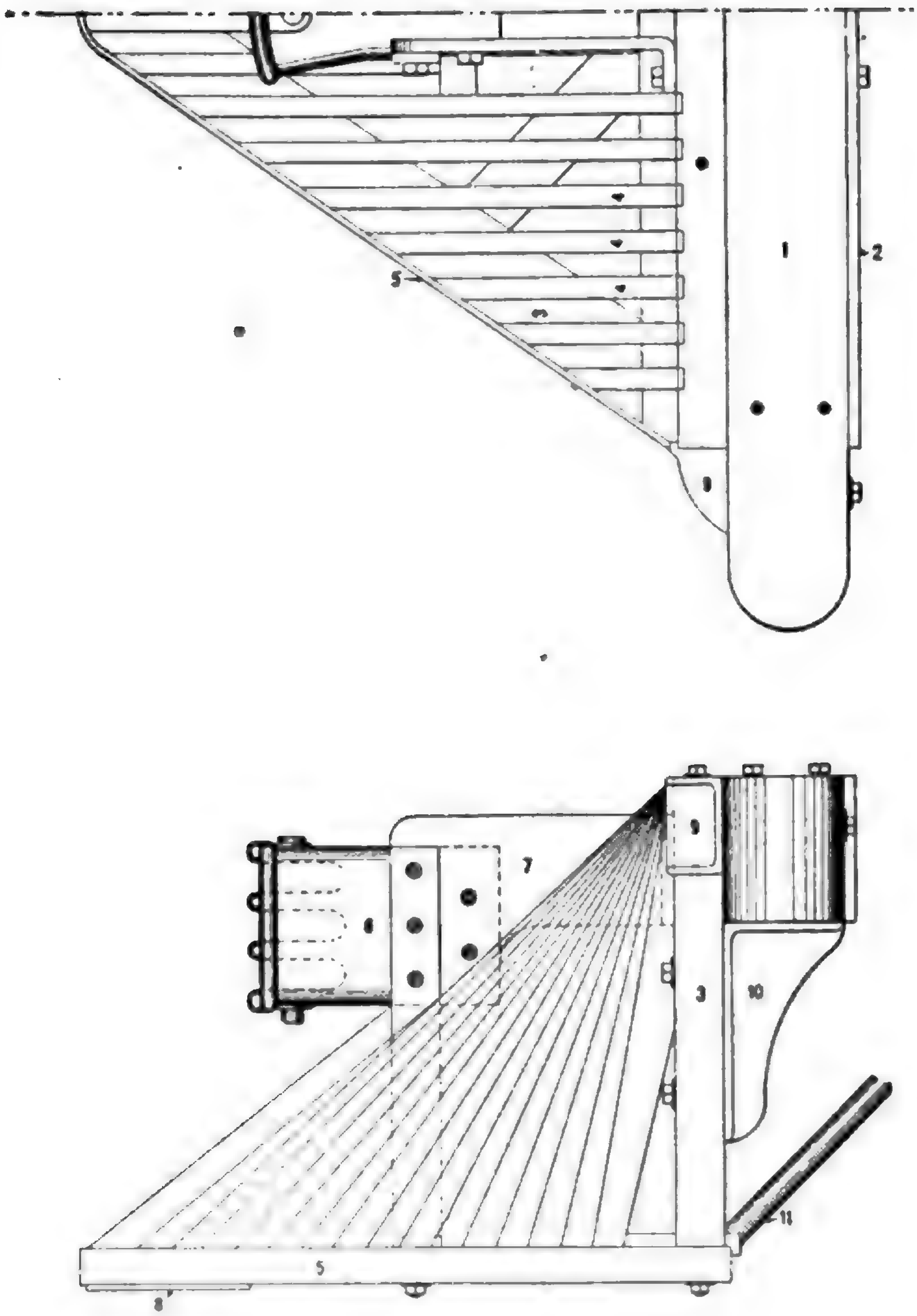
Pedestal Box.—See Journal Box.

Petroleum Burner.—See Oil Burner.

Pet Cock.—Small cock usually at the bottom of a pump, water pipe or elsewhere, to drain it when desired. Was formerly used in feed pipe to show if pump was working.

Piston Packing: Dunbar.—This consists of two kinds of rings, one square and the other L-shape, which carries the square ring. Each is cut in sections and put together with joints staggered. Under the L ring are a number of round steel wire springs. The follower plate clamps these in any desired position.

Piston Speed.—The speed in feet per minute that a piston travels. As it makes two strokes (in and out) for each revolution, multiply the stroke of piston in feet, by 2 and by revolutions of wheels per minute.



Pilot.—1. Bumper. 2. Stiffening plate. 3. Pilot frame. 4. Pilot bars. 5. Bottom band. 6. Draw casting. 7. Support for draw casting. 8. Bottom plate. 9. Pushing shoe. 10. Pilot bracket. 11. Middle brace.

Piston Speed.—Multiply stroke in feet by 2 and by revolutions per minute.

Example: 26 inch stroke = 2 1-6 feet multiplied by 2 = 4 1-3 feet. At 102 revolutions per minute equals 4 1-3 times 200, or 866 feet per minute.

Piston Valves.—See Valve Piston.

Pony Truck.—Name given to a two wheel or half truck to distinguish from a full or four wheel truck. The method of connection is shown in sketch. See Truck.

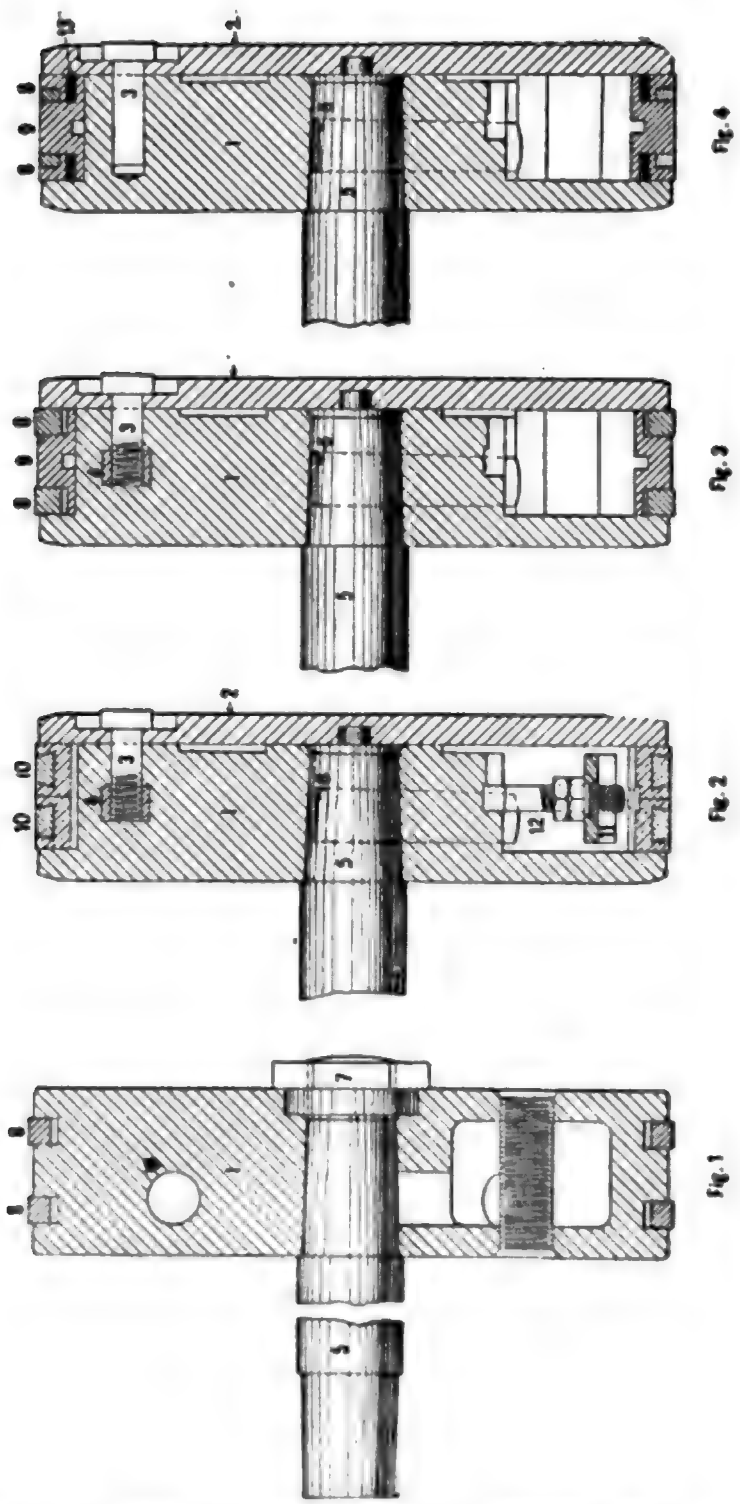
Pooling Locomotives.—Keeping the locomotives at work all of the time not necessary for inspection and repairs. Some run these regardless of which crew takes them out, being a case of first come, first serve. Others put two or three crews on one run and use the same engine as far as possible for that run. As with all changes of methods it has been abused in places, but on the whole is found cheaper in every way.

Poppet Valve.—A valve lifting from a flat or angular seat. Not a piston valve. A double poppet is one having two seats as a large number of throttle valves are now made.

Portland Cement.—First made by Joseph Aspdin, Leeds, Eng., in 1824. Called "Portland" from its resemblance to the famous building stone quarried at Portland, England. Made of lime and clay calcined and mixed with water.

Prairie Locomotive.—Pony truck, 6 coupled drivers and a pair of trailers.

Pre-Admission of Steam.—See Steam—Pre-admission of



Pistons.—1. Piston head. 2. Follower. 3. Follower bolts. 4. Follower bolt nuts. 5. Piston rod. 6. Piston rod key. 7. Piston rod nut. 8. Piston spring rings, cast iron. 9. T ring, cast iron. 10. Brass and composition rings. 11. Spring. 12. Piston spring studs and nuts. 13. Piston wire springs.

Pneumatic Tool Data.—

Kind of Work	Dimensions of Work	Weight of Tools	Free Air used per Minute
Chipping Caulking	¼ to ⅞ in. metal	8 to 12 pounds	10 to 14 cu. ft.
Riveting	¾ to 1¼ in. rivets	16 to 25 pounds	16 to 23 cu. ft.
Drilling......	⅜ to 3 in. in steel	18 to 60 pounds	16 to 35 cu. ft.
Reaming.....	¼ to 2¼ in. in steel	18 to 60 pounds	16 to 35 cu. ft.
Tapping	¼ to 2¼ in. in steel	18 to 60 pounds	16 to 35 cu. ft.
Boring Wood.	1 to 3 inches hardwood	12 to 28 pounds	16 to 27 cu. ft.
Flue Rolling.	2 to 6 in.	12 to 58 pounds	27 to 35 cu. ft.
Foundry Work	Ramming Moulds	18 to 280 pounds	11 to 25 cu. ft.
Stone Work..	Dressing and Carving	3 to 10 pounds	

Always use strainers at the inlet. Oil once an hour with a good light oil; heavy oil becomes thick at the low temperature of the air and tool. Pressure should be 80 to 100 pounds at the tool. Have tools cleaned thoroughly and carefully two or three times a month. Blow them out often.

Pressure: Absolute.—Total pressure counting from a perfect vacuum. As the pressure of the atmosphere at sea level is taken at 14.7 pounds, absolute pressure is gage pressure plus 14.7 pounds. Thus 180 pounds gage pressure is 194.7 absolute. See Pressure—Gage.

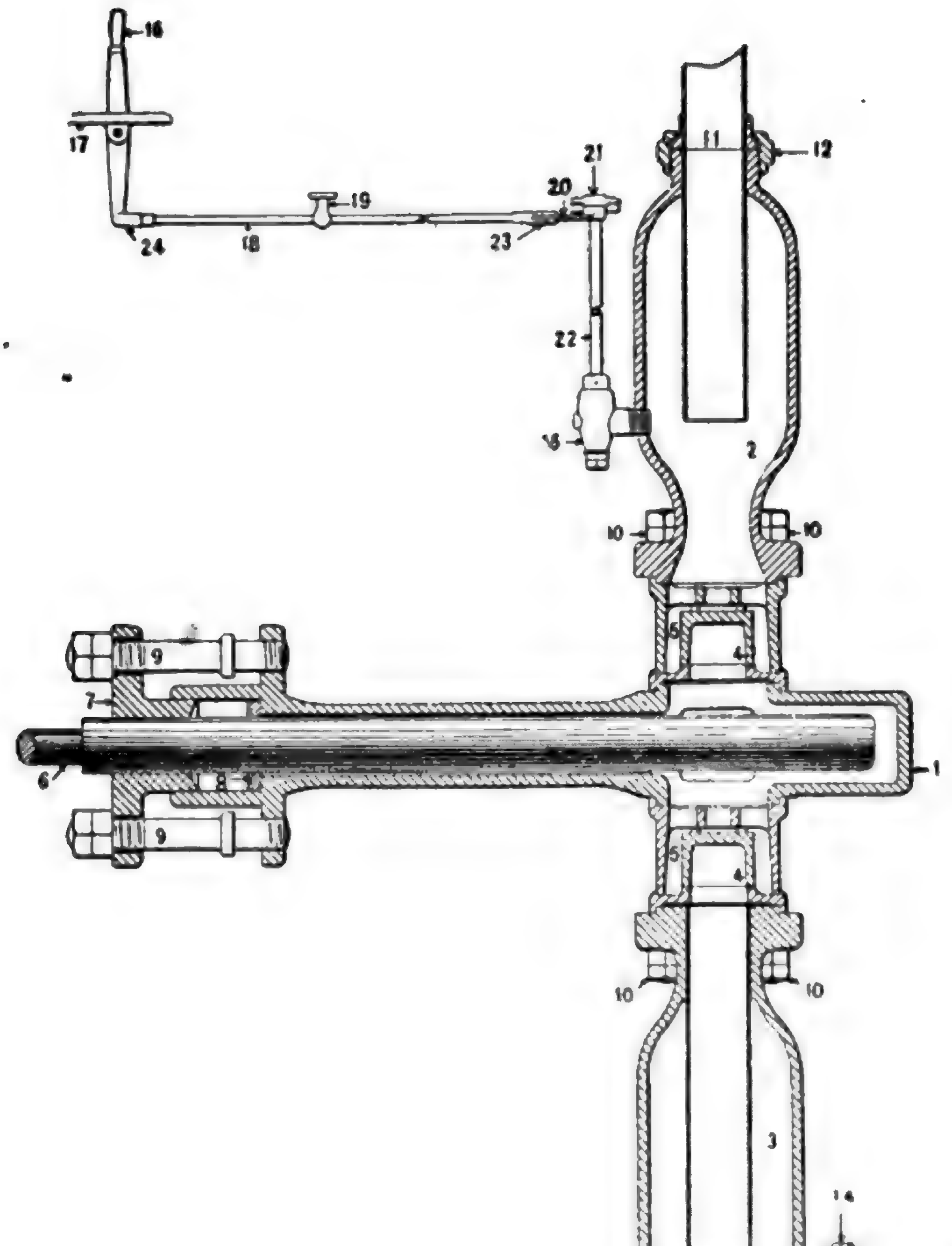
Pressure: Gage.—The amount of pressure registered by a gage is 14.7 pounds less than absolute as the atmospheric pressure (14.7 pounds above a perfect vacuum) presses against both sides of the registering tube or diaphragm. Gage pressure is the one we use in locomotive work, except in calculating expansion. See Pressure Absolute.

Priming.—The raising of water from boiler in a body or small particles. This goes into steam pipe and to cylinders. Often confused with foaming.

Projected Area.—As applied to bearings, is the diameter multiplied by the length. An 8×12 inch bearing would have a projected area of 96 square inches.

Pull-iron.—See Drawbar.

Pump Governors.—Controls pump by air pressure.



Pump.

Pump.—1. Pump barrel, 2. Top chamber. 3. Bottom chamber. 4. Valve. 5. Cage. 6. Plunger. 7. Gland. 8. Bottom ring. 9. Gland studs. 10. Chamber studs. 11. Check pipe. 12. Coupling nut. 13. Feed pipe. 14. Coupling. 15. Pet cock. 16. Pet cock lever in cab. 17. Fulcrum. 18. Rod. 19. Guide. 20. Crank. 21. Hanger. 22. Rod. 23. Jaw. 24. Lever.

Q

Queen Post.—See Truss Rod Bearing.

R

Radial Stays.—Staybolts which are in radial lines from the center of the boiler. Do not extend to center but, if continued, would meet there. Give a direct resistance to bursting strains and are largely used.

Radiation.—A 2″ bare pipe with steam at 60 lbs., with coal at $4.00 per ton, costs $1 per foot per year. Calling heat loss 1,000 heat units magnesia will save 738—radiating but 262. Properly clothed radiating surfaces save $30 to $40 per sq. foot per year.

85 per cent. Magnesia Carbonate.
15 per cent. Asbestos.

Radiation of Heat.—The passage through the air of heat rays from a heated body. If the hand approaches a hot steam pipe, the heat is felt before the pipe is touched. Boilers and cylinders radiate much heat in the air. To prevent this as much as possible they are covered or lagged with some substance which does not readily conduct heat, such as asbestos, magnesia or mineral wool.

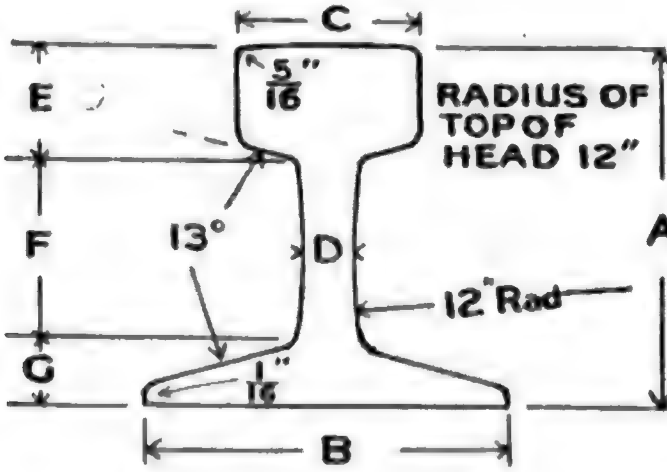
Rails Elevation on Curves. See Curves.

Railroad Operation.—Cost of June 30, 1903.

Fixed charges to maintain equipment.

		Per Cent.
Superintendence	$7,017,635	30.725
Shop Machinery	8,739,157	38.262
Stationery	575,881	2.525
Other Expenses	6,507,168	28.488

Rails.—Dimensions of.



Pounds per Yd.	A		C	D	E	F	G
100	5 3-4	5 3-4	2 3-4	9-16	1 45-94	3 5-64	31-32
95	5 9-16	5 9-16	2 11-16	9-16	1 41-64	2 63-64	15-16
90	5 3-8	5 3-8	2 5-8	9-16	1 19-32	2 55-64	59-64
85	5 3-16	5 3-16	2 9-16	9 16	1 35-64	2 3-4	7-8
80	5	5	2 1-2	35-64	1 1-2	2 5-8	57-64
75	4 13-16	4 13-16	2 15-32	17-32	12 7-64	2 35-64	27 32
70	4 5-8	4 5-8	2 2-16	33-64	1 11-32	2 15-32	13-16
65	4 7-16	4 7-16	2 13-32	1-2	1 9-32	2 3-8	25-32
60	4 1-4	4 1-4	2 3-8	31-64	1 7-32	2 17-64	49-64
55	4 1-16	4 1-16	2 1-4	15-32	1 11-64	2 11-64	23-32
50	3 7-8	3 7-8	2 1-8	7-16	1 1.8	2 1-16	11-16
45	3 11-16	3 11-16	2	27 64	1 1-16	1 31-32	21-32
40	3 1-2	3 1-2	1 7-8	25-64	1 1-64	1 55-64	5-8

Rails: Expansion of—Allowance for different temperatures of weather.

Thermometer	90 deg. or over,	allow	1-32 inch
"	70 to 90 deg.,	allow	1-16 "
"	50 to 70 deg.,	allow	⅛ "
"	30 to 50 deg.,	allow	3-16 "
"	10 to 30 deg.,	allow	¼ "
"	10 ab. to 10 b'lw,	allow	5-16 "

Rails.—Manganese Steel. Cost $5 per foot; Bessemer rails cost 38 cents per foot. Being used on Boston Elevated for bad curves. Wear enough longer to pay. Cast—cannot be rolled. —1905.

RAILS:—

Weight is given in pounds per yard. Rails are generally 30 feet or 10 yards long, although a few are 60 feet long, and there seems to be a tendency toward a compromise length of 45 feet. As a mile is 5,280 feet, or, 1,760 yards, there are 176 rail lengths per mile, so that a mile of single track road requires 352 rails.

At 100 pounds per yard a single rail will weigh 1,000 pounds and the two rails for a single track weigh 2,000 pounds, or 1 ton. The rails, then, weigh one ton for each 30 feet, or 176 tons per mile. The weight per yard, divided by 100, gives the weight in tons per rail length for a single track as $\frac{60}{100} = \frac{6}{10}$ tons per rail length.

The weight in tons per mile will be $\frac{176 \text{ x weight per yd}}{100}$ or, 1.76 x weight per yard.

It is generally assumed that light steel rails will carry 10 pounds (on a point) per ton of 2,240 pounds with ties properly spaced. This, reduced to the short or 2,000 pound ton, makes it nearly 9 pounds to the ton. On this basis a locomotive weighing 56,000 pounds, on four driving wheels, or, 14,000 pounds on a wheel, would require a 63 pound rail as a minimum. Multiplying the weight in tons on a given point by 9 gives the minimum weight of rail.

Reversing this, to find the weight a 90 pound rail can carry, gives 90, divided by 9 = 10 tons, 20,000 pounds on a wheel. This is exceeded in some cases, but is considered good practice.

This equals 17.5 tons (of 2000 lbs.) per mile of single track road for every square inch of cross section. Then we have a formula as follows:

$$\frac{\text{Weight in lbs. per yd.}}{10}$$

$$\text{or } \frac{\text{Weight in tons (2000 lbs.) per mile of single track}}{17.5} =$$

area of rail in square inches.

If a mile of single track weighs 120 tons, then the rail will have a section of $\frac{120}{17.5} = 6.85$ square inches. Or, working it the other way, a rail having a section of 6.85 square inches will weigh 6.85 x 17.5 tons per mile of single track. This rail would also weigh 6.85x10 = 68.5 pounds per yard.

$$\text{Tons (2240 lbs.) of rail per mile of single tr'k} = \frac{11 \times \text{weight of rail in lbs. per yd.}}{7}$$

or, for tons of 2,000 lbs. this can be read:

$$\text{Tons (2000 lbs.) of rail per mile of single tr'k} = \frac{10 \times \text{weight of rail in lbs. per yd.}}{5.68}$$

The sectional area of a rail in square inches multiplied by 10 gives the pounds per yard of single rail.

Ratios of Cylinders.—Relation or proportion one bears to the other. Used mostly in speaking of compound locomotives. If the high pressure cylinder was 10 inches in diameter and the low 20 inches, the ratio is 1 to 4 because circular areas vary as the square of the diameter. So, as $10 \times 10 = 100$ and $20 \times 20 = 400$ we see the ratio is 1 to 4.

Receiver.—In a compound locomotive is the name given to the space in the connection between the high and low pressure steam

chests. After exhaust leaves the high pressure cylinder it passes through the receiver into low pressure steam chest.

Receiver Pressure.—Pressure of steam in receiver. Some jacket the receivers with steam to keep steam pressure in the receiver. Others allow a drop in pressure. Few engineers now use a steam jacket on the receiver.

Reducing Valve.—Valve to reduce pressure. Either to give a fixed pressure regardless of pressure on boiler or to reduce pressure to a given percentage of that on boiler. The latter are called differential reducing valves and are used on nearly all two cylinder compounds.

Repair Charges.—Average of many large roads given as follows by Interstate Commerce Commission:

Locomotives	42.792	per	cent.
Passenger Cars	11.8	"	"
Freight and Work Cars ...	44.390	"	"
Marine Dept.	1.018	"	"

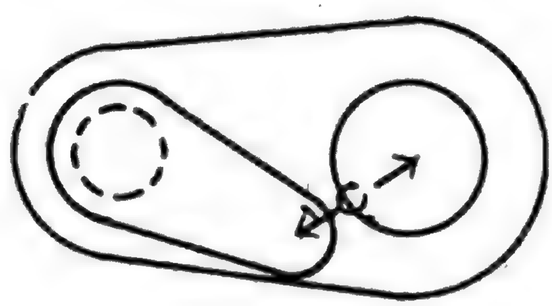
Repairs.—Mallet compound on B. & O., cost of labor and material for repairs was \$3.16 per 100 miles run. Electric locomotives on same roads cost \$6.10 per 100 miles run, counting both electrical and mechanical repairs.

Repairs.—See Locomotives, cars or subjects wanted.

Retaining Ring.—A ring used for keeping tires in place on wheel centers. The tires are shrunk on as usual and fit against a shoulder on the inside while the retaining ring prevents it slipping should it be expanded by excessive braking.

Retardation.—Opposite of Acceleration.

Return Crank.—An auxiliary crank of less throw than the main crank as shown. Formerly used to drive feed pumps, but now seldom seen except with Wahlschaert Valve Gear. The real or effective throw is the distance C.



Return Crank.

Resistance of Trains.—See Train Resistance.

Revolutions per Mile.—1680 divided by diameter of wheel in felt or

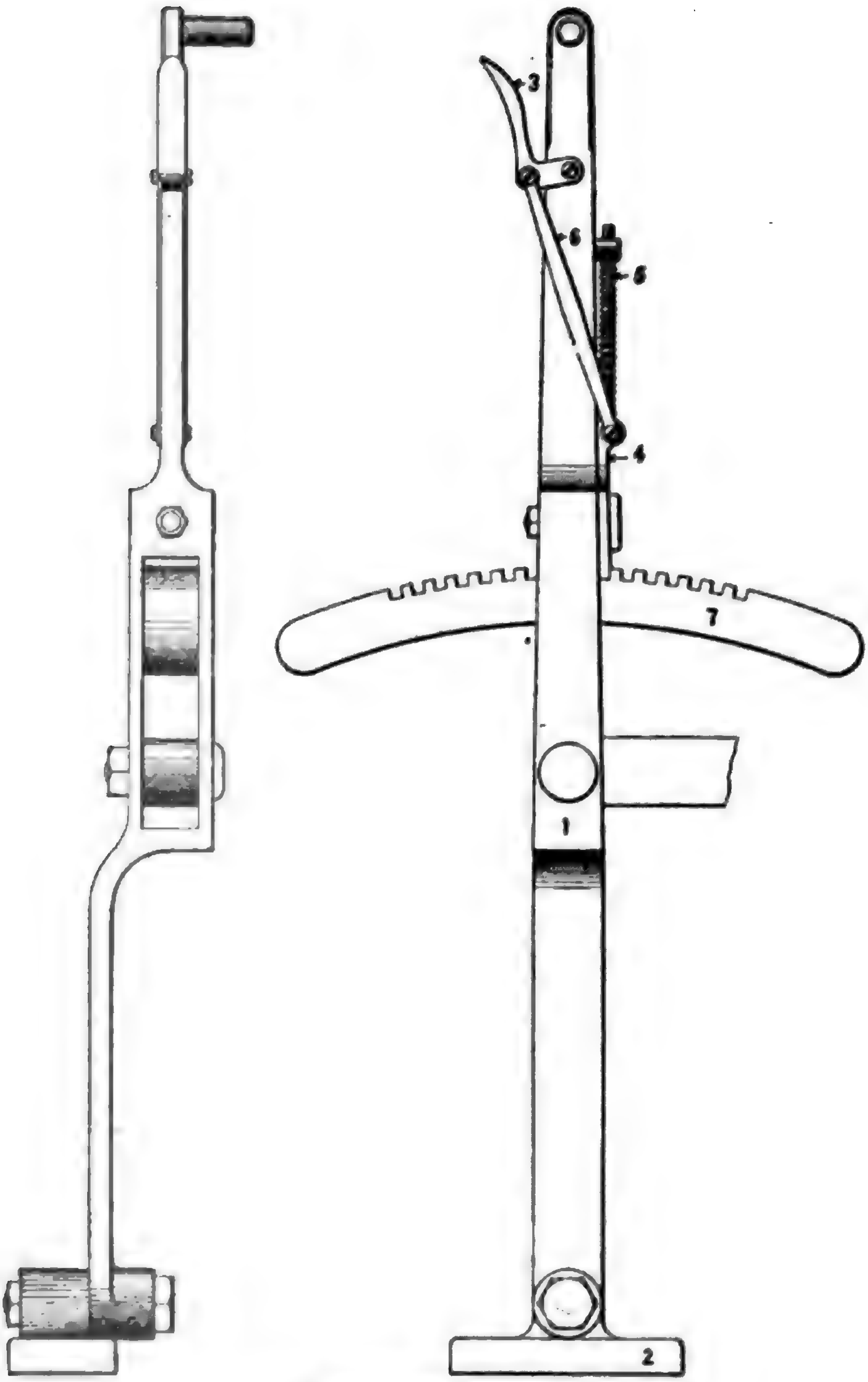
$$R = \frac{1680}{\text{Diam. in feet}} \text{ or } \frac{20160}{\text{Diam. in inches.}}$$

Example: Wheel 66 inches, or 5½ feet. 1680 divided by 5½ = 305½ (nearly).

Revolutions per Minute.—Multiply speed in miles per hour by 28 and divide product by diameter of driving wheel in feet, or

$$R = \frac{\text{Speed in miles per hour x 28.}}{\text{Diameter of wheel in feet.}}$$

Example: Same wheels as above at 20 miles per hour.
20 x 28 = 560 ÷ diam. of wheel.



Reverse Lever.

Reverse Lever.—1. Lever. 2. Fulcrum. 3. Handle. 4. Latch. 5. Spring 6. Rod. 7. Catch.

Rigid Wheel Base.—Greatest distance between rigid wheels. This is generally the distance between front and rear drivers but may extend to front or rear, carrying wheels if they are rigid in frame.

Riveting Dies.—Life of. Dies made of tool steel. Life depends on steel, pressure, kinds of rivets, etc. Varies from a few hundred to several thousand rivets. Is then re-shaped and used again.

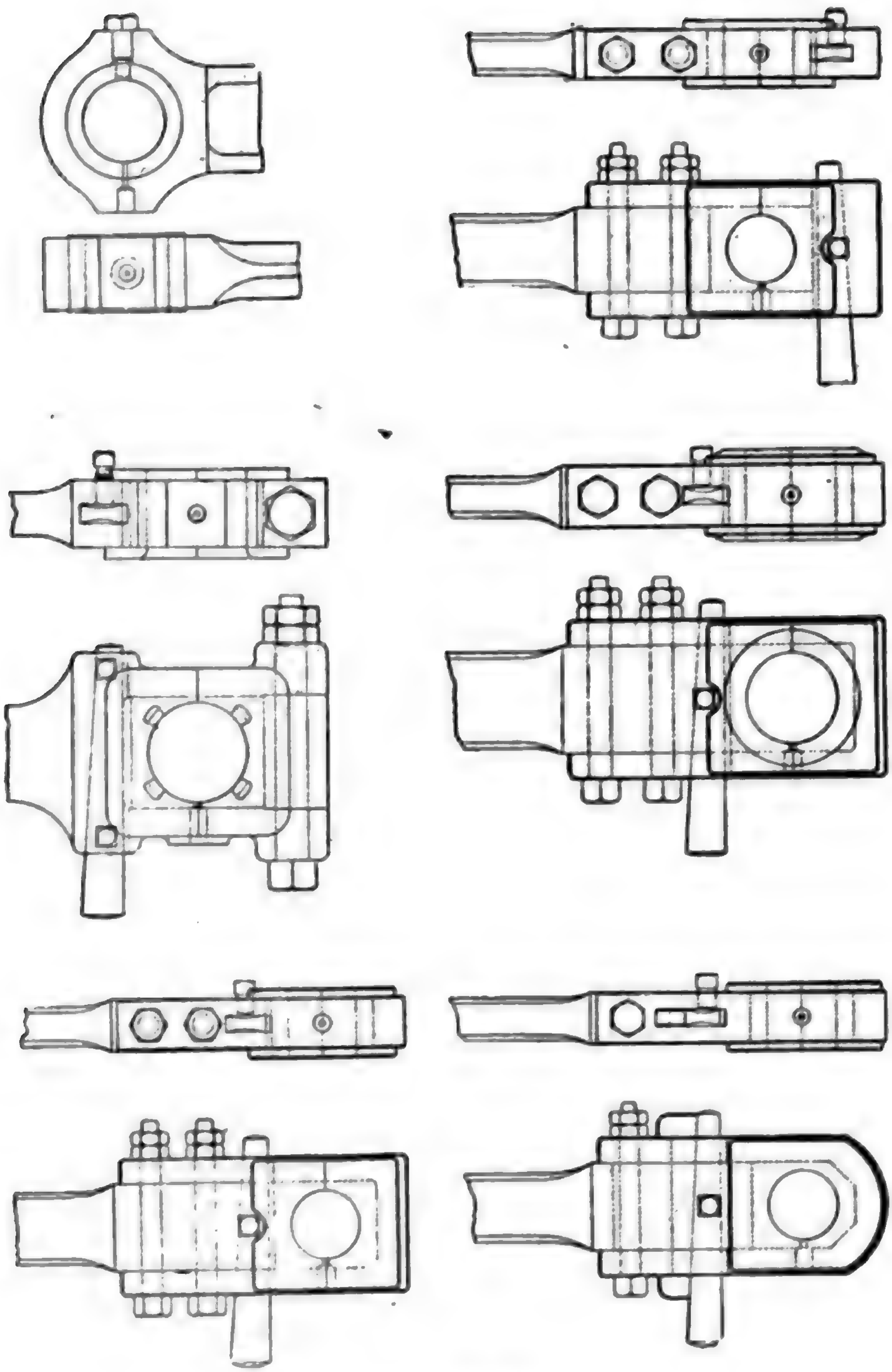
Riveting.—Pressure Required. Based on a fibre stress of 60,000 lbs to the square inch on the head of the rivet, the pressure should be as follows:

½ inch	18 tons	1 inch	63 tons
⅝ inch	26 "	1¼ inch	95 "
¾ inch	36 "	1⅜ inch	114 "
⅞ inch	48 "	1½ inch	135 "

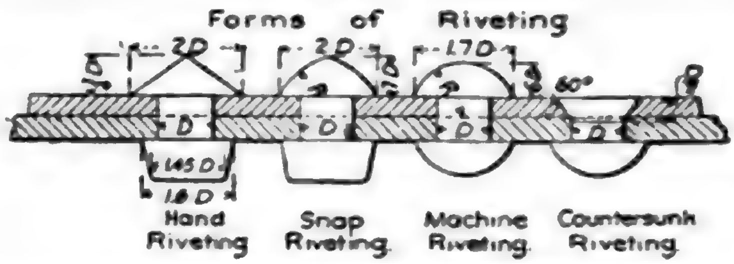
Rocker Arm.—Arm (or lever) which transmits motion, generally between link and valve. In locomotive work it usually reverses the motion and makes an indirect motion.

Roller Valve.—A valve having a series of small rollers between valve and seat, at each end of ports to reduce friction on valves. Patentered by Bristol. Never largely used and now obsolete. Practically impossible to keep tight if rollers are to carry any of the weight. See Valves—Bristol.

Rod End.—End of main or connecting rods. Used in speaking of the various styles in use. Some of the most prominent forms are:



Rod Ends.



Tensile Strength of Plate per 1 inch of Width

Thickness	Tensile strength per square inch				
	50000	55000	60000	65000	70000
1/16	3125	3437	3750	4062	4375
1/8	6250	6875	7500	8125	8750
3/16	9375	10312	11250	12187	13125
1/4	12500	13750	15000	16250	17500
5/16	15625	17187	18750	20312	21875
3/8	18750	20625	22500	24375	26250
7/16	21875	24062	26250	28437	30625
1/2	25000	27500	30000	32500	35000
9/16	28125	30937	33750	36562	39375
5/8	31250	34375	37500	40625	43750
11/16	34375	37812	41250	44687	48125
3/4	37500	41250	45000	48750	52500
13/16	40625	44687	48750	52812	56875
7/8	43750	48125	52500	56875	61250
15/16	46875	51562	56250	60937	65625
1	50000	55000	60000	65000	70000

Shearing Strength of Rivets (Single Shear)

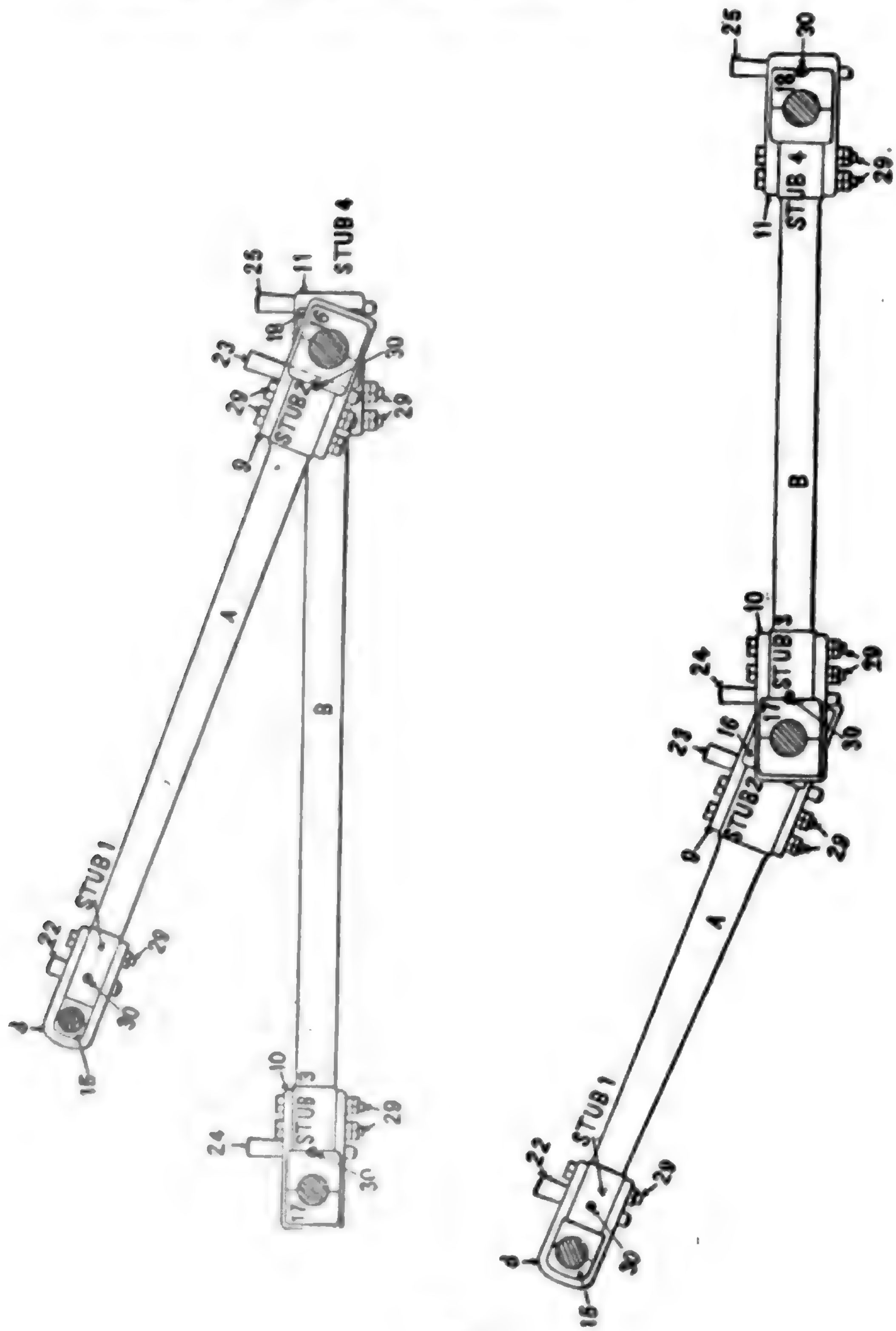
Diam. of Rivet	Area of Cross-Section	Shearing Strength per Square inch				
		30000	35000	40000	45000	50000
3/8	1104	3312	3864	4416	4968	5520
1/2	1963	5889	6870	7852	8835	9815
5/8	.3068	9204	10738	12272	13806	15340
3/4	4418	13254	15463	17672	19881	22090
7/8	.6013	18039	21045	24052	[illegible]	30065
1	7854	23562	27489	31416	35343	39270

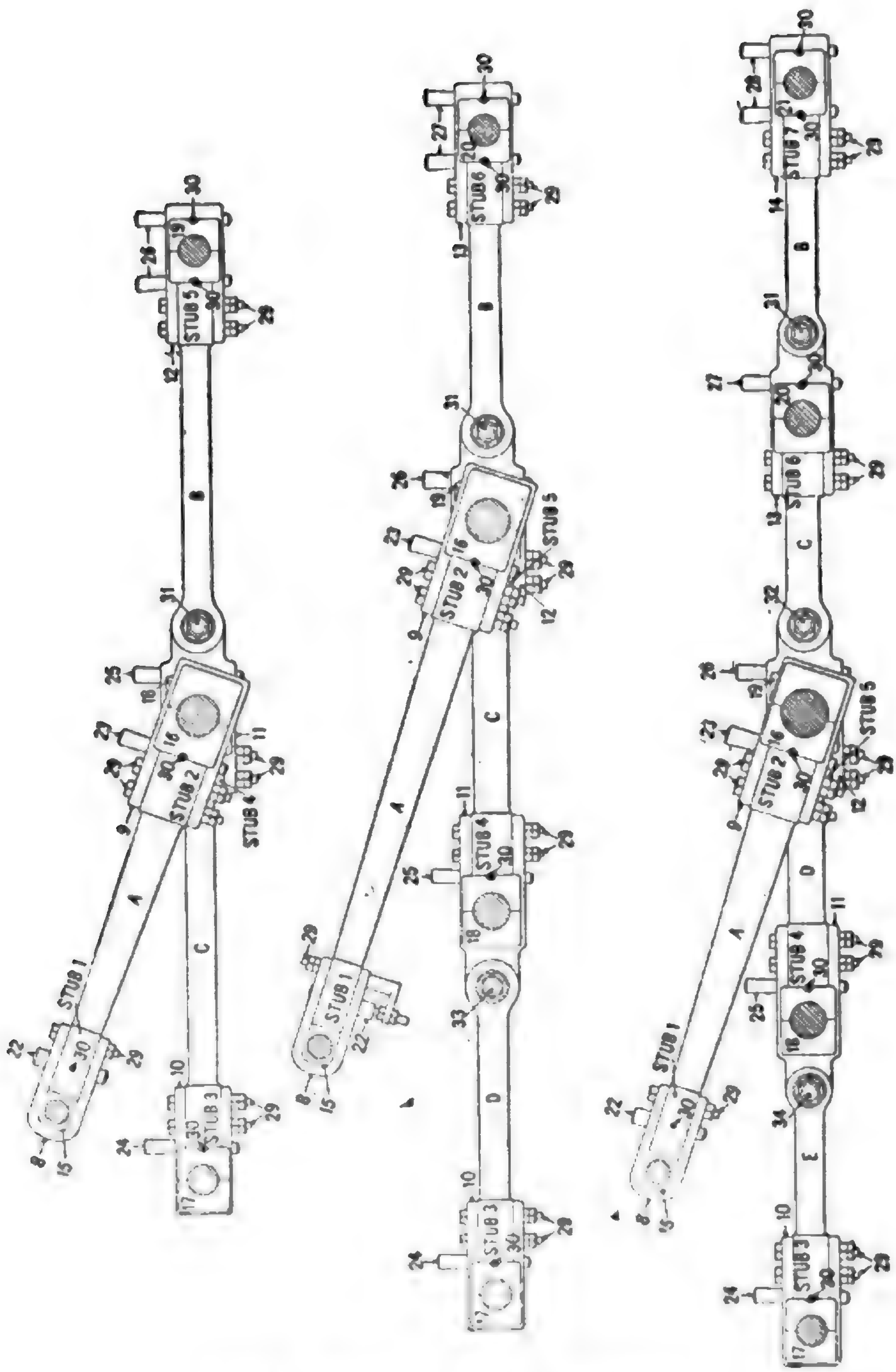
Crushing Strength of Rivets

The crushing strength of rivets and plates, in joints that fail by crushing, is found by experiment to be high and irregular. In some cases it has amounted to 150,000 lbs per square inch, in a few tests it has been less than 85,000 lbs per square inch. A value of 95,000 lbs. may be used with safety for general calculations.

<u>Riveting.—Speed of.</u> Large riveters sometimes drive eighty or ninety rivets per hour. Too rapid riveting cannot be done without sacrificing quality of work. The sheets should be held together until rivet cools off sufficiently to hold them.

Rods, Straps and Brasses.—A. Main rod. B. Back parallel or side rod. C. Second parallel or side rod. D. Third parallel or side rod. E. Fourth parallel or side rod. 8. Strap of stub 1. 9. Strap of stub 2. 10. Strap of stub 3. 11. Strap of stub 4. 12. Strap of stub 5. 13. Strap of stub 6. 14. Strap of stub 7. 15 to 21. Brasses. 22 to 28. Keys. 29. Bolt. 30. Set screw, 31 to 34. Jaw pins.





Rods, Straps and Brasser.

S

Saddle Tank Locomotive.—One with water tank over the boiler, or on sides, or both. Used on shifting (switching or drilling) engines. Capacity is usually small and adhesion varies with water in tanks.

Safety Plug.—See fusible plug.

Safety Valve.—Coale, 3-inch muffled. Popped 59 times for 6,960 seconds. 3,680 lbs. of steam escaped.

Another Test. Popped 35 times in 3.654 seconds. 1,928 lbs. of steam escaped. Averages about ½ lb. per second.

Sand.—Mallet compound on B. & O, run as a helper and slow freight, runs 485 miles per ton of sand.

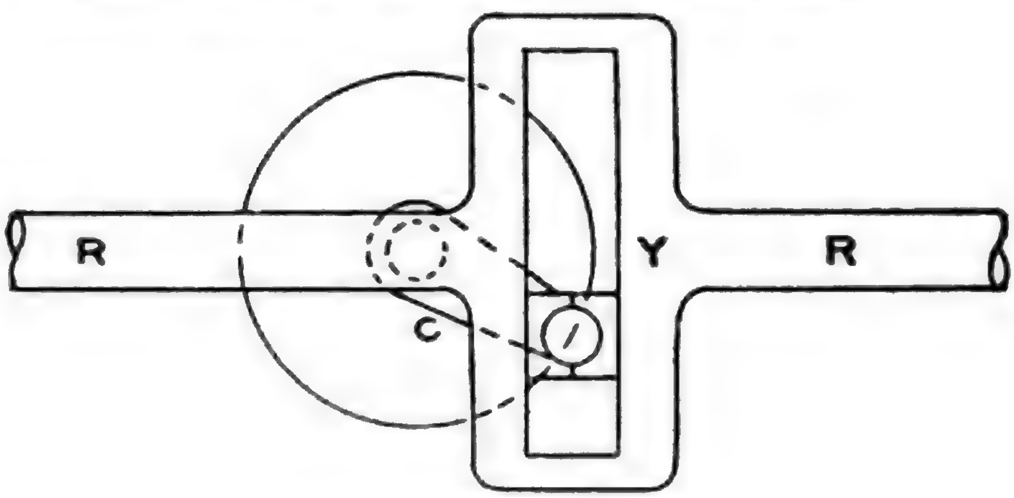
Sand Dryer.—The C. M. & St. P. Ry. use a rotary sand dryer consisting of what is practically a boiler shell 27½ inches in diameter by 17 feet 5 inches long. At the ends are old 33-inch tires for rings which rest on rollers. Inside are angle irons riveted in spiral form to give 1½ turns in the length of cylinder. These agitate the sand and slow down its movement, the cylinder being set at an incline.

Sand is fed into upper end and works down to the lower end which is fitted with a screen. The cylinder is mounted over a brick setting same as a boiler and has a fire under it. With about 6 feet of grate it dries about one cubic yard per hour.

Saturated Steam.—See Steam, Saturated.

Scale.— Cost of. The Ry. M. M. Asso., estimate that the losses due to scale, which means extra repairs, loss of fuel, etc., averages $750 per year per locomotive in the Middle and Western States.

Scotch Yoke.—A slotted crosshead in which crank pin revolves. It forces the crosshead back and forth without any angular distortion such as occurs if rods are used.



Scotch Yoke.

C—Crank, Y—Yoke, R R, Rod.

Scoop.—Name sometimes given to coal shovel.

Scoop.—Device used in taking or scooping water from track tank between rails, with train in motion. The scoop is controlled by fireman who drops it and raises it at the proper time. In some cases, mostly English, it is

handled by steam under control of fireman. man.

P. R. R. gets tank full at 12 to 15 miles per hour; 10 miles sometimes gets it. Midland, of England, could not scoop at 16 miles; consider 25 miles the minimum. Difference in shape of scoops: P. R. R. is an easy curve; Midland was an abrupt turn at bottom.

Semaphore.—Name given to signal which uses a post and signal arms to show position of switches.

Semaphore Arm.—The movable arm pivoted to the signal mast, and by the position of which the indications are given.

Semaphore Blade.—The part of the semaphore arm which by its form and position gives the day signal indications.

Serve Tube.—See Tubes.

Shackle Bar.—See Drawbar.

Shell.—See Journal Box.

Shops: Capacity of—Careful calculating by L. R. Pomeroy and others shows that the shop capacity of a road or division should be 10 per cent. of the locomotives to be handled. That is a division having 100 engines should have shoproom and equipment for handling 10 of these at a time. Of this capacity, 8 per cent. should be in the shop, and 2 per cent. can be handled in the roundhouse. The shop then, should have 8 tracks and the roundhouse 2 repair tracks.

Shops:—Heating of—Air passed over heated pipes and forced into the shop by fans

seems to be the system used in all the newer shops. In some shops there is a distributing system of pipes, while in others it is simply discharged into one end or one side of the shop and allowed to distribute itself over the whole place. This can be materially aided by having all or at least half the air that goes over the heated pipes, drawn from different parts of the shops. This creates a curent of air and distributes warm air in different portions of the shops.

The velocity of the heated air in the fan outlets should not exceed 2500 feet per minute and 2000 is better. In the branches, if there are any, 800 to 1200 feet per minute is amply.

By maintaining a slight pressure of air—which can readily be done by drawing part of the air supply from outside—most of the leakage of cold air in around the windows can be prevented, it being forced out by the pressure inside. This will have a tendency to keep the floors and lower portions of the shop warmer.

Signals.—See Train Order Signals.

Signal Banjo.—Name given to a kind of signal resembling a banjo in appearance; usually electrically operated and many are of the Hall Signal Co. make.

Signal.—Distance. A warning signal which shows the engineer what to expect at the home signal. The home signal may clear before train reaches it, but enigneer is governed by distance signal as to speed in approaching "home" signal.

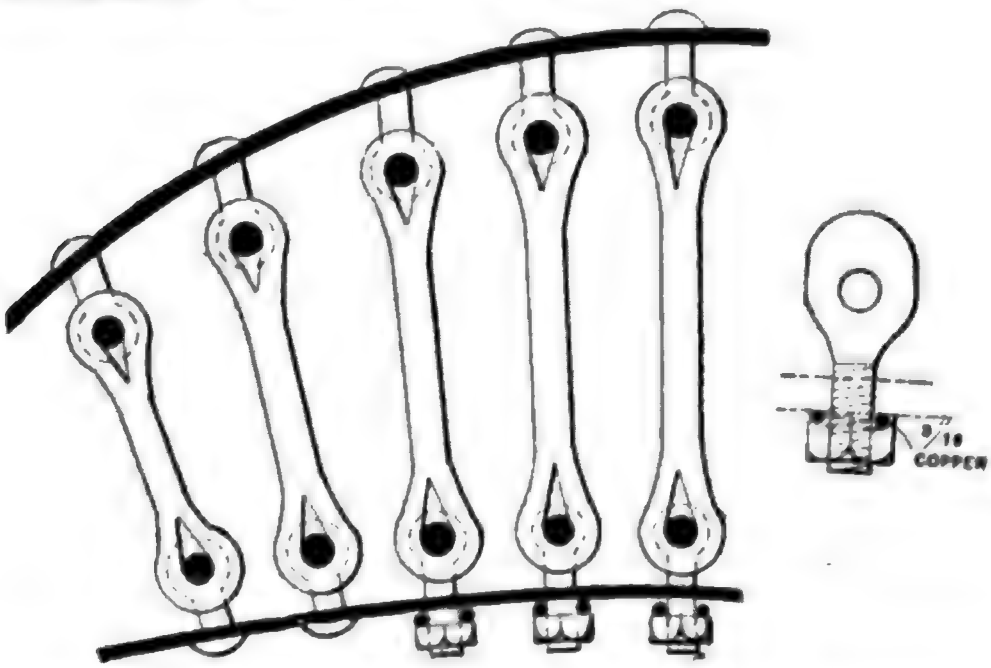
Signal.—Home. The signal nearest the point to be protected.

Single Acting Engine.—Engines in which steam is used on one side of piston only. Requires no stuffing box for piston rod. Not used in locomotives but employed in some stationary engines and nearly all gas engines.

Single Expansion, or Simple Locomotives. Locomotives in which the steam is admitted, expanded in one cylinder and exhausted to atmosphere. See compound locomotives.

Sleepers.—See Ties.

Slide Bar.—See Guide Bar.



Sling Stays.—Allow sheets to move together, but resist steam pressure between them.

Slip of Block.—In a link motion the block has a certain movement in the link which does not produce motion of valve. This is called "slip of block" and varies according to design of valve motion. Many think it a great detriment and strive to avoid it, but it really does little, if any, harm.

Slotted Crosshead.—See Scotch Yoke.

Smoke Box Temperature.—Varies from 250 to 700 degrees Fahrenheit; average about 450 degrees.

Smoke Stacks.—There have been various kinds and styles. Modern practice is the straight or practically straight stack. Wood burner —diamond—bottom straight.

Smoke Box.—See Front End.

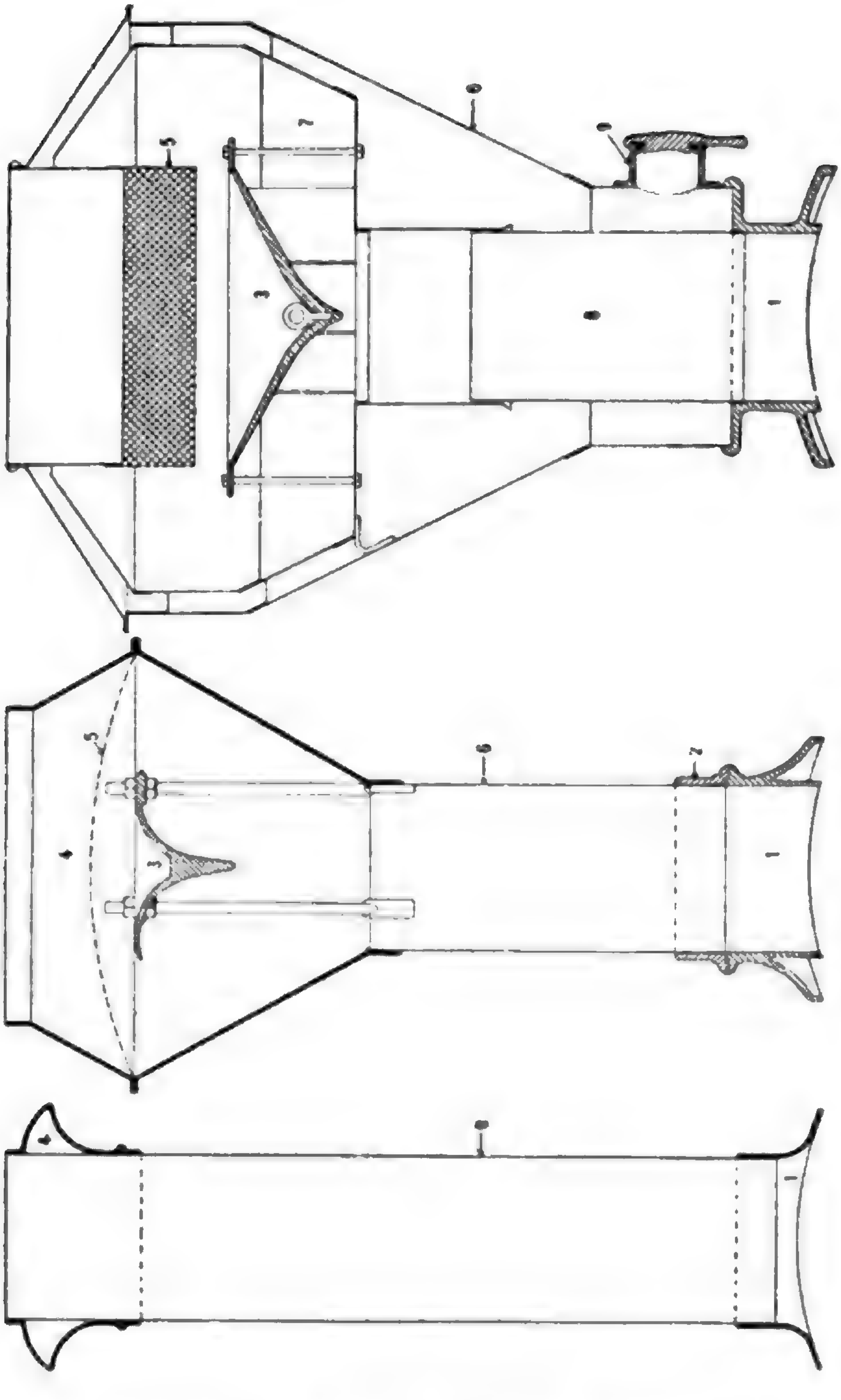
Solid Staybolt.—See Staybolt.

Sparks.—Loss of heat or fuel by sparks thrown from stack 10.98 to 12.95 per cent. of value of fuel. Hitchcock—A. S. M. E. Vol. 25.

Sparks.—Tests at Purdue University and in actual service by Prof. W. F. M. Goss show that the danger or fire from sparks of a locomotive is very remote and that the danger line can be fixed at 100 feet from the railroad track. Numerous tests showed that at this distance there was not heat enough in such sparks as reached this distance to scorch unbleached cotton muslin.

Tests of the locomotive at 15 and 55 miles per hours, showed the weight of sparks thrown out to vary almost directly with the draft and speed of engine. The ratio of the total weight of cinders (including those thrown out of stack and those caught in the front end) to the weight of coal fired; varied from .043 to .151—the latter at 55 miles per hour. Average was about .06 to .07.

Specific Gravity.—Weight of a body as compared with the same volume of water at 39 degrees Fahr. Specific gravity of zinc is 7 because a cubic foot of zinc weighs 7 times as much as a cubic foot of water.



Smoke Stack.—1. Base. 2. Base flange. 3. Cone. 4. Top. 5. Netting. 6. Body. 7. Chamber. 8. Inside pipe. 9. Hand hole and plate.

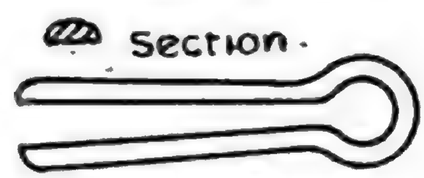
Specific Heat.—The heat required to raise any body one degree as compared with the heat required to raise water the same amount. The specific heat of wrought iron is .1138, which means that it only requires .1138 of a heat unit to raise the temperature of wrought iron one degree.

Speeds.—See Train Speeds.

Sphere.—Surface. Circum. × diameter. It is equal to curved surface of cylinder having diam. and length = to diam. of sphere.

Volume. Cube diameter × 3.1416 and ÷ 6 or cube diam. × 0.5236.

Split Key.—Sometimes called a cotter. A half-round wire or rod bent to sort of a hair-pin-shape with flat sides together.



Stacks for Locomotives.—Practice varies. Von Borries recommends following proportions: Diameter of choke of stack = .8 × cylinder diameter. Diameter of choke of stack = 3.8 × diam. of single exhaust nozzle.

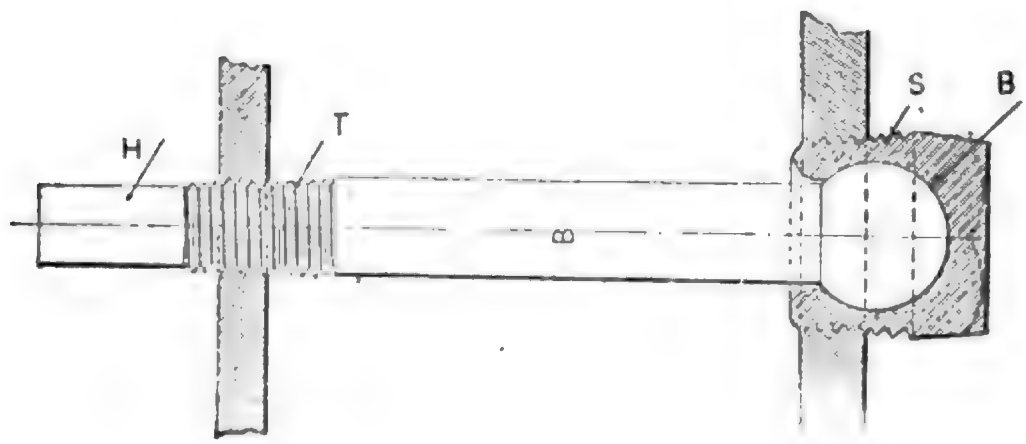
From top of nozzle to top of stack = 14 × diameter of nozzle.

From choke to top of stack = 8.4 × diam. of nozzle.

Staybolt.—Hollow. Name usually applied to staybolts rolled hollow or drilled their entire length; the latter is rarely resorted to. Some staybolts are drilled into far enough to show a leak if a break occurred inside the sheet. They are usually drilled after putting in place. Those rolled hollow, with hole

clear through, are coming into better favor. Some have holes punched in while hot before being used.

Staybolts.—Flexible. One free to move at one end to conform to expansion of sheets. There are several kinds, only one being shown.



Flexible Staybolt.

Staybolts.—Radial. A method of using staybolts which radiate from the center of the boiler as shown. This refers to staybolts around top of firebox where crown bars were formerly used. See Crown Bars.

Staybolt.—Solid. One screwed solidly into both sheets, depending on flexibility of staybolt material or sheet, or both, to accommodate expansion of sheet.

Stationary Link Motion.—See Valve Gears.

Steam.—A vapor made by boiling water. This vapor condenses on being cooled and returns to water. It is a very expansive vapor and

occupies about 1646 times the space of the water from which it was evaporated, unless confined so as to increase pressure. The volume decreases with the pressure and the temperature increases with it.

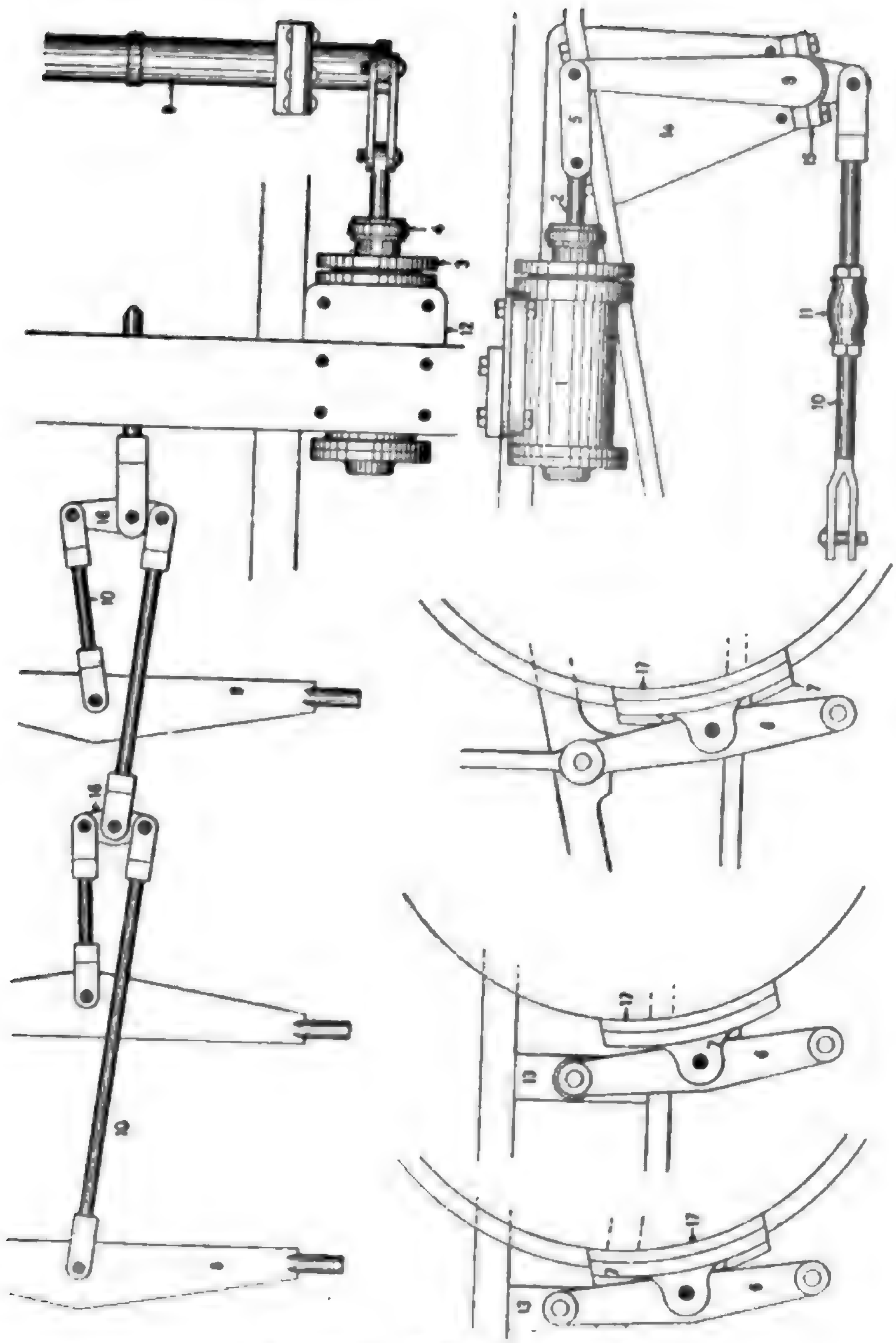
Steam Consumption of Locomotive.—

Boiler Pressure by Gage	Mean Effective Pressure Average for Four Cylinder Ends	Least Back Pressure Average for Four Cylinder Ends	Weight of steam per 1 H. P. per hour by tank	Weight of mixture in Cylinders per revolution	Percentage of whole weight of mixture account'd for as steam at release	Range of temperature in Cylinders
98.4	29.37	3.1	28.8	1.052	84.4	110.9
123.0	42.17	5.5	26.3	1.303	84.6	119.0
143.3	50.79	7.2	24.8	1.454	85.6	127.0

Tests by Prof. W. F. M. Goss, 1896. Throttle wide open, cut-off 8″. Speed 188 revolutions, 35 miles per hour.

Steam, Pre-Admission of. Admission of steam before piston reaches end of stroke. When valve opens to give its lead the live steam rushes into cylinder and aids compression in cushioning piston.

Steam Brake Work.—1. Brake cylinder. 2. Piston rod. 3. Cylinder head. 4. Stuffing box nuts. 5. Connecting link. 6. Lever. 7. Head. 8. Beam. 9. Shaft. 10. Rod. 11. Adjusting nut. 12. Cylinder support. 13. Hanger. 14. Shaft support. 15. Bearing. 16. Rod lever. 17. Shoe.



Steam Brake Work.

Steam.—Saturated. Steam in contact with water, as in a locomotive or other boiler, is known as saturated. The temperature depends on the pressure and varies with it. Saturated steam always contains some moisture. See Superheated steam.

Steam.—Superheated. If saturated steam be allowed to flow into the receiver away from the water in boiler, it may then be heated to almost any temperature without increasing pressure. In some cases this has been done up to 750 degrees which, with saturated steam, would be equal to over 1500 lbs. pressure. Experiments on the Moselle and Nahe Ry., in 1903-4, show that locomotives using superheated steam burn 6.3 per cent. less coal, but use 22 per cent more oil for lubrication.

Steam.—Wire Drawn. When steam is admitted to the cylinders through a restricted or partly closed opening, it is said to be wire drawn. This reduces the pressure and also tends to give cylinder dryer steam. Throttling a locomotive "wire draws" the steam.

Steel Tired Wheels, Life of.—Average of 100 steel-tired wheels, 33 inches in diameter, passenger service gave 265,000 miles as life of wheel. Some ran as high as 380,000 miles.

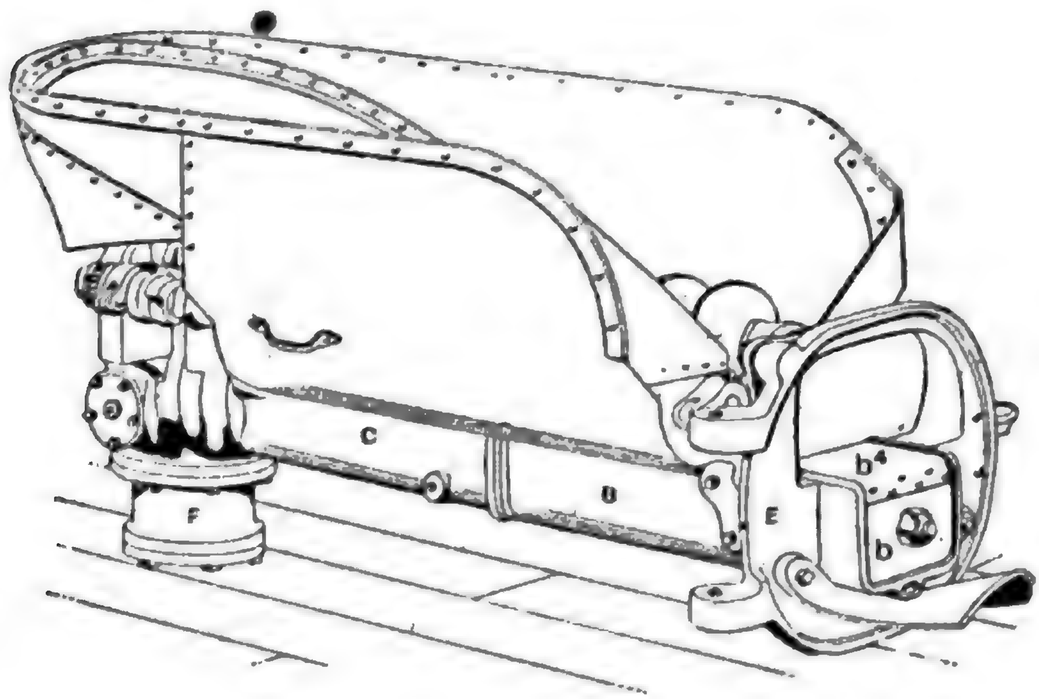
PROPERTIES OF SATURATED STEAM.

Absolute Pressure.	Gage Pressure.	Temperature F.	Weight in Pounds per Cubic Foot of Steam.	Volume in Cubic Feet of One Pound of Steam.	Total Heat above 32° F. In the Water. Heat Units.	Total Heat above 32° F. In the Steam. Heat Units.	Latent Heat. Heat Units.
1	27.9	102.1	.003	334.23	70.09	1113.1	1043.0
5	19.7	162.3	.014	72.50	130.7	1131.4	1000.7
10	9.6	193.2	.026	37.80	161.9	1140.9	979.0
14.7	0.	212.0	.038	26.36	180.9	1146.6	965.7
15	.3	213.0	.039	25.87	181.9	1146.9	965.0
20	5.3	227.9	.050	19.72	197.0	1151.5	954.4
25	10.3	240.0	.063	15.99	209.3	1155.1	945.8
30	15.3	250.2	.074	13.48	219.7	1158.3	938.9
35	20.3	259.2	.086	11.66	228.8	1161.0	932.2
40	25.3	267.1	.097	10.28	236.9	1163.4	926.5
45	30.3	274.3	.109	9.21	244.3	1165.6	921.3
50	35.3	280.9	.120	8.34	251.0	1167.6	916.6
55	40.3	286.9	.131	7.63	257.2	1169.4	912.3
60	45.3	292.5	.142	7.03	262.9	1171.2	908.2
65	50.3	297.8	.153	6.53	268.3	1172.8	904.5
70	55.3	302.7	.164	6.09	273.4	1174.3	900.9
75	60.3	307.4	.175	5.71	278.2	1175.7	897.5
80	65.3	311.8	.186	5.37	282.7	1177.0	894.3
85	70.3	316.0	.197	5.07	287.0	1178.3	891.3
90	75.3	320.0	.208	4.81	291.2	1179.6	888.4
95	80.3	323.9	.219	4.57	295.1	1180.7	885.6
100	85.3	327.6	.230	4.36	298.9	1181.8	882.9
110	95.3	334.5	.251	3.98	306.1	1184.0	877.9
120	105.3	341.0	.272	3.67	312.8	1185.9	873.2
130	115.3	347.1	.294	3.41	319.1	1187.8	868.7
140	125.3	352.8	.315	3.18	325.0	1189.5	864.6
150	135.3	358.2	.336	2.98	330.6	1191.2	860.6
160	145.3	363.3	.357	2.80	335.9	1192.7	856.9

PROPERTIES OF SATURATED STEAM (Continued).

Absolute Pressure.	Gage Pressure.	Temperature F.	Weight in Pounds per Cubic Foot of Steam.	Volume in Cubic Feet of One Pound of Steam.	Total Heat above 32° F. In the Water, Heat Units.	Total Heat above 32° F. In the Steam, Heat Units.	Latent Heat, Heat Units.
170	155.3	368.2	.378	2.65	340.9	1194.2	853.3
180	165.3	372.8	.398	2.51	345.8	1195.7	849.9
190	175.3	377.3	.419	2.39	350.4	1197.0	846.6
200	185.3	381.6	.440	2.27	354.9	1198.3	843.4
210	195.3	385.7	.461	2.17	359.2	1199.6	840.4
220	205.3	389.7	.485	2.06	362.2	1200.8	838.6
230	215.3	393.6	.506	1.98	366.2	1202.0	835.8
240	225.3	397.3	.527	1.90	370.0	1203.1	833.1
250	235.3	400.9	.548	1.83	373.8	1204.2	830.5
260	245.3	404.4	.569	1.76	377.4	1205.3	827.9
270	255.3	407.8	.589	1.70	380.9	1206.3	825.4
280	265.3	411.0	.610	1.64	384.3	1207.3	823.0
290	275.3	414.2	.630	1.585	387.7	1208.3	820.6
300	285.3	417.4	.651	1.535	390.9	1209.2	818.3
350	335.3	432.0	.755	1.325	406.3	1213.7	807.5
400	385.3	444.9	.857	1.167	419.8	1217.7	797.9
450	435.3	456.6	.959	1.042	432.2	1221.3	789.1
500	485.3	467.4	1.062	.942	443.5	1224.5	781.0
550	535.3	477.5	1.164	.859	454.1	1227.6	773.5
600	585.3	486.9	1.266	.790	464.2	1230.5	766.3
650	635.3	495.7	1.368	.731	473.6	1233.2	759.6
700	685.3	504.1	1.470	.680	482.4	1235.7	753.3
750	735.3	512.1	1.572	.636	490.9	1238.0	747.2
800	785.3	519.6	1.674	.597	498.9	1240.3	741.4
850	835.3	526.8	1.776	.563	506.7	1242.5	735.8
900	885.3	533.7	1.878	.532	514.0	1244.7	730.6
950	935.3	540.3	1.980	.505	521.3	1246.7	725.4
1000	985.3	546.8	2.082	.480	528.3	1248.7	720.3

Stoker.—Mechanical. Machine which throws the coal into the firebox in place of hand firing. See cut of Kincaid Stoker—now called Victor.



Kincaid (Victor) Mechanical Stoker.

B—Ram casing, C—Steam cylinder, b—Ram which throws coal over curved spreading plate. Coal is thrown or fed into hopper and fed in front of ram by the worm or screw conveyor shown inside the hopper.

ROTATIVE SPEED TABLE FOR MILES PER HOUR.

Diameter in inches.	Circumference in feet.	Revolutions per mile.	Revolutions per Minute, at Miles per Hour							
			10	15	25	35	40	55	65	75
18	4.712	1119.76	186.62	279.94	466.55	653.17	746.48	1026.42	1213.08	1399.65
20	5.236	1008.4	168.07	252.1	420.17	588.24	672.28	924.38	1092.45	1260.52
22	5.759	916.8	152.4	229.2	381.6	534	609.6	838.8	991.2	1143.6
24	6.283	838.4	139.7	209.6	349.3	489	558.8	767.4	908.1	1047.8
26	6.81	775.3	129.2	193.8	323	452.2	516.8	710.6	839.8	969.
28	7.33	720.3	120	180.1	300.1	420.1	480	660.1	780.1	900.1
30	7.85	672.6	112.1	168.15	280.25	392.35	448.4	616.55	728.65	840.75
32	8.377	630.8	105.05	157.57	262.62	367.67	420.2	577.77	682.82	787.87
33	8.64	611.1	101.85	152.8	254.65	356.5	407.40	560.2	662.05	763.9
34	8.901	593.2	98.8	148.3	247.1	345.9	395.2	543.5	642.3	741.1
36	9.42	560.5	93.4	140.1	233.5	326.9	373.6	513.7	607.1	700.5
37	9.686	545.1	90.8	136.3	227.1	317.9	363.3	499.5	590.3	681.1
38	9.95	530.6	88.4	132.4	220.8	309.2	353.6	486	574.4	662.8
40	10.47	504.2	84.03	126.05	210.08	294.11	336.12	462.17	546.2	630.23
42	11.00	480.0	80	120	200	280	320	440	520.	600
44	11.52	458.3	76.4	114.6	191	267.4	305.6	420.1	496.6	573.
46	12.04	438.5	73.1	109.6	182.7	255.8	292.4	402	475.1	548.2
48	12.57	420.0	70	105	180	250	280	385	460	530.
50	13.09	403.4	67.2	100.85	168	235.3	268.8	369.65	436.8	504.
52	13.61	387.9	64.6	97	161.6	226.2	258.4	355.4	420	484.6
54	14.14	373.4	62.2	93.3	155.5	217.7	248.8	342.1	404.3	466.5
56	14.66	360.2	60.03	90.05	150.1	210.13	240.13	330.17	390.22	450.25
58	15.18	347.8	57.9	86.9	144.8	202.7	231.6	318.5	376.4	434.8
60	15.71	336.1	56.01	84.02	141	197.01	224.04	308.1	365.04	421.05
62	16.23	325.3	54.2	81.3	135.5	189.7	216.8	298.1	352.3	406.5
64	16.75	315.2	52.5	78.7.	131.2	183.7	210	288.7	341.3	393.7
66	17.28	305.5	50.9	76.4	127.3	178.2	203.6	280.	330.9	[illegible]
68	17.80	296.6	49.4	74.1	123.5	173.	197.6	271.7	321.1	370.6
70	18.33	288.1	48.0	72	120	168	192	264	312.	360.
72	18.85	280.1	46.7	70	116.7	163.4	186.8	256.8	303.5	350.2
78	20.42	258.6	43.1	64.6	107.7	150.8	172.4	237	280.1	323.2
84	21.99	240.1	40	60	100	140	160	220	260	300
90	23.56	224.1	37.3	56	92.8	129.6	149.2	205.2	241.5	278.8
96	25.16	210.1	35	52.5	87.5	122.5	140	192.5	227.5	262.5

The rate of miles per hour has been so chosen that by doubling any of them the intermediate speeds of 20, 30, 50, 70, 80, etc., can be had. The column of revolutions per mile gives revolutions per minute for 60 miles per hour. Almost any other speed can be found by adding two columns such as 10 and 75.

EQUIVALENTS OF TIME AND SPACE TRAVERSED.

Miles per Hour	Feet per Hour	Feet per Minute	Feet per Second	Time per Mile Min	Time per Mile Sec.	Time per Mile Seconds	Miles per Hour	Feet per Hour	Feet per Minute	Feet per Second	Time per Mile Min	Time per Mile Sec.	Time per Mile Seconds
1	5,280	88	1.46	60	..	3,600	31	163,680	2,728	45.46	1	56	116
2	10,560	176	2.93	30	..	1,800	32	168,960	2,816	46.93	1	52	112
3	15,840	264	4.39	20	..	1,200	33	174,240	2,904	48.39	1	49	109
4	21,120	352	5.86	15	..	900	34	179,520	2,992	49.86	1	45	105
5	26,400	440	7.33	12	..	720	35	184,800	3,080	51.33	1	42	102
6	31,680	528	8.80	10	..	600	36	190,080	3,168	52.80	1	40	100
7	36,960	616	10.26	8	34	514	37	195,360	3,256	54.26	1	37	97
8	42,240	704	11.73	7	30	450	38	200,640	3,344	55.73	1	34	94
9	47,520	792	13.19	6	40	400	39	205,920	3,432	57.19	1	32	92
10	52,800	880	14.66	6	..	360	40	211,200	3,520	58.66	1	30	90
11	58,080	968	16.13	5	27	327	41	216,480	3,608	60.13	1	27	87
12	63,360	1,056	17.60	5	..	300	42	221,760	3,696	61.60	1	25	85
13	68,640	1,144	19.06	4	36	276	43	227,040	3,784	63.06	1	23	83
14	73,920	1,232	20.52	4	17	257	44	232,320	3,872	64.52	1	21	81
15	79,200	1,320	22.00	4	..	240	45	237,600	3,960	66.00	1	20	80
16	84,480	1,408	23.46	3	45	225	46	242,880	4,048	67.46	1	18	78
17	89,760	1,496	24.93	3	31	211	47	248,160	4,136	68.93	1	16	76
18	95,040	1,584	26.39	3	20	200	48	253,440	4,224	70.39	1	15	75
19	100,320	1,672	27.86	3	9	189	49	258,720	4,312	71.86	1	13	73
20	105,600	1,760	29.33	3		180	50	264,000	4,400	73.33	1	12	72
21	110,880	1,848	30.80	2	51	171	51	269,280	4,488	74.80	1	10	70
22	116,160	1,936	32.26	2	43	163	52	274,560	4,576	76.26	1	9	69
23	121,440	2,024	33.73	2	36	156	53	279,840	4,664	77.73	1	7	67
24	126,720	2,112	35.19	2	30	150	54	285,120	4,752	79.19	1	6	66
25	132,000	2,200	36.66	2	24	144	55	290,400	4,840	80.66	1	5	65
26	137,280	2,288	38.13	2	18	138	56	295,680	4,928	82.13	1	4	64
27	142,560	2,376	39.60	2	13	133	57	300,960	5,016	83.60	1	3	63
28	147,840	2,464	41.06	2	8	128	58	306,240	5,104	85.06	1	2	62
29	153,120	2,552	42.53	2	4	124	59	311,520	5,192	86.52	1	1	61
30	158,400	2,640	44.00	2		120	60	316,800	5,280	88.00	1		60

ROTATIVE SPEED TABLE FOR MILES PER HOUR.

Diameter in inches.	Circumference in feet.	Revolutions per mile.	Revolutions per Minute, at Miles per Hour							
			10	15	25	35	40	55	65	75
18	4.712	1119.76	186.62	279.94	466.55	653.17	746.48	1026.42	1213.03	1399.65
20	5.236	1008.4	168.07	252.1	420.17	588.24	672.28	924.38	1092.45	1260.52
22	5.759	916.8	152.4	229.2	381.6	534	609.6	838.8	991.2	1143.6
24	6.283	838.4	139.7	209.6	349.3	489	558.8	767.4	908.1	1047.8
26	6.81	775.3	129.2	193.8	323	452.2	516.8	710.6	839.8	969.
28	7.36	720.8	120	180.1	300.1	42[illegible].1	480	660.1	780.1	900.1
30	7.85	672.6	112.1	168.15	280.25	392.35	448.4	616.55	728.65	840.75
32	8.377	630.3	105.05	157.57	262.62	367.67	420.2	577.77	682.82	787.87
33	8.64	611.1	101.85	152.8	254.65	356.5	407.40	560.2	662.05	763.9
34	8.901	593.2	98.8	148.3	247.1	345.9	395.2	543.5	642.3	741.1
36	9.42	560.5	93.4	140.1	233.5	326.9	373.6	513.7	607.1	700.5
37	9.686	545.1	90.8	136.3	227.1	317.9	363.2	499.5	590.3	681.1
38	9.95	530.6	88.4	132.4	220.8	309.2	353.6	486	574.4	662.8
40	10.47	504.2	84.03	126.05	210.08	294.11	336.12	462.17	546.2	630.23
42	11.00	480.0	80	120	200	280	320	440	520.	600
44	11.52	458.3	76.4	114.5	191	267.4	305.6	420.1	496.6	573.
46	12.04	438.5	73.1	109.6	182.7	255.8	292.4	402	475.1	548.2
48	12.57	420.0	70	105	180	250	280	385	460	530.
50	13.09	403.4	67.2	100.85	168	235.2	268.8	369.65	436.8	504.
52	13.61	387.9	64.6	97	161.6	226.2	258.4	355.4	420	484.6
54	14.14	373.4	62.2	93.3	155.5	217.7	248.8	342.1	404.3	466.5
56	14.66	360.2	60.03	90.05	150.1	210.13	240.12	330.17	390.22	450.25
58	15.18	347.8	57.9	86.9	144.8	202.7	231.6	318.5	376.4	434.8
60	15.71	336.1	56.01	84.03	141	197.01	224.04	308.1	365.04	421.05
62	16.23	325.3	54.2	81.3	135.5	189.7	216.8	298.1	352.3	406.5
64	16.75	315.2	52.5	78.7.	131.2	183.7	210	288.7	341.2	393.7
66	17.28	305.5	50.9	76.4	127.3	178.2	203.6	280.	330.9	[illegible].8
68	17.80	296.6	49.4	74.1	123.5	173.	197.6	271.7	321.1	370.6
70	18.36	288.1	48.0	72	120	168	192	264	312.	360.
72	18.85	280.1	46.7	70	116.7	163.4	186.8	256.8	303.5	350.3
78	20.42	258.6	43.1	64.6	107.7	150.8	172.4	237	280.1	323.3
84	21.99	240.1	40	60	100	140	160	220	260	300
90	23.56	224.1	37.3	56	93.3	129.6	149.3	205.2	241.5	278.8
96	25.13	210.1	35	52.5	87.5	122.5	140	192.5	227.5	262.5

The rate of miles per hour has been so chosen that by doubling any of them the intermediate speeds of 20, 30, 50, 70, 80, etc., can be had. The column of revolutions per mile gives revolutions per minute for 60 miles per hour. Almost any other speed can be found by adding two columns such as 10 and 75.

EQUIVALENTS OF TIME AND SPACE TRAVERSED.

Miles per Hour	Feet per Hour	Feet per Minute	Feet per Second	Time per Mile Min	Time per Mile Sec.	Time per Mile Seconds	Miles per Hour	Feet per Hour	Feet per Minute	Feet per Second	Time per Mile Min	Time per Mile Sec	Time per Mile Seconds
1	5,280	88	1.46	60	..	3,600	31	163,680	2,728	45.46	1	56	116
2	10,560	176	2.92	30	..	1,800	32	168,960	2,816	46.92	1	52	112
3	15,840	264	4.39	20	..	1,200	33	174,240	2,904	48.38	1	49	109
4	21,120	352	5.86	15	..	900	34	179,520	2,992	49.86	1	45	105
5	26,400	440	7.32	12	..	720	35	184,800	3,080	51.33	1	43	102
6	31,680	528	8.80	10	..	600	36	190,080	3,168	52.80	1	40	100
7	36,960	616	10.26	8	34	514	37	195,360	3,256	54.26	1	37	97
8	42,240	704	11.73	7	30	450	38	200,640	3,344	55.73	1	34	94
9	47,520	792	13.19	6	40	400	39	205,920	3,432	57.19	1	32	92
10	52,800	880	14.66	6	..	360	40	211,200	3,520	58.66	1	30	90
11	58,080	968	16.12	5	27	327	41	216,480	3,608	60.12	1	27	87
12	63,360	1,056	17.60	5	..	300	42	221,760	3,696	61.60	1	25	85
13	68,640	1,144	19.06	4	36	276	43	227,040	3,784	63.06	1	23	83
14	73,920	1,232	20.52	4	17	257	44	232,320	3,872	64.52	1	21	81
15	79,200	1,320	22.00	4	..	240	45	237,600	3,960	66.00	1	20	80
16	84,480	1,408	23.46	3	45	225	46	242,880	4,048	67.46	1	18	78
17	89,760	1,496	24.92	3	31	211	47	248,160	4,136	68.92	1	16	76
18	95,040	1,584	26.39	3	20	200	48	253,440	4,224	70.39	1	15	75
19	100,320	1,672	27.86	3	9	189	49	258,720	4,312	71.86	1	13	73
20	105,600	1,760	29.33	3		180	50	264,000	4,400	73.33	1	12	72
21	110,880	1,848	30.80	2	51	171	51	269,280	4,488	74.80	1	10	70
22	116,160	1,936	32.26	2	43	163	52	274,560	4,576	76.26	1	9	69
23	121,440	2,024	33.73	2	36	156	53	279,840	4,664	77.73	1	7	67
24	126,720	2,112	35.19	2	30	150	54	285,120	4,752	79.19	1	6	66
25	132,000	2,200	36.66	2	24	144	55	290,400	4,840	80.66	1	5	65
26	137,280	2,288	38.12	2	18	138	56	295,680	4,928	82.12	1	4	64
27	142,560	2,376	39.60	2	13	133	57	300,960	5,016	83.60	1	3	63
28	147,840	2,464	41.06	2	8	128	58	306,240	5,104	85.06	1	2	62
29	153,120	2,552	42.52	2	4	124	59	311,520	5,192	86.52	1	1	61
30	158,400	2,640	44.00	2		120	60	316,800	5,280	88.00	1		60

Street Railway.—Cost of. Electric railways in England cost from $19,467 to $29,209 per mile of single track, divided as follows: Rails and fastenings 22 per cent; special work, 10 per cent.; paving material, 30 per cent.; cement, sand and broken stone 14 per cent.; labor 15 per cent.; bonds, cartage, etc., 9 per cent. Tramway and Light Ry. Asso., 1905.

Stub End.—See Rod End.

Strut.—A supporting piece used to brace a rod, beam or frame.

Sub-way.—In railroad work, a depression under tracks or streets, meaning going under or below the surrounding surface.

Superheated Steam.—See Steam Superheated.

Swing Beam.—See Truck Bolster.

Swing Bolster.—See Truck Bolster.

Swing Log.—See Truck Bolster.

Swinnerton Wheel.—A patented driving wheel having flat spots or facets cut on the driving wheel to give it greater adhesion on the rail. Tried on the Central R. R. of N. J., and the New York Elevated, a complete failure. Built in 1888.

T

Tandem Compound.—See Locomotive Compound.

Tandem, Baldwin.—Similar to Schenectady, except for details. No cross ports. Crane on smoke box to assist in handling. First one built for Santa Fe in 1902.

Tandem, Schenectady.—Four cylinder tandem type. Piston valves, crossed ports on high pressure cylinder. First one built for Northern Pacific August, 1901.

Temperature by Fahrenheit and Centigrade.—

$$\text{F to C} = \frac{5(\text{F}-32)}{9} = \text{C}$$

$$\text{C to F} = \frac{9\text{C}}{5} + 32 = \text{F}$$

Example: 212° Fahr. = 212 less 32 = 180. Divide by 9 = 20. Multiply by 5 = 100.

100° Cent. = 9 times 100 = 900. Divide by 5 = 180. Add 32 = 212.

Water boils at 1 degree less temperature for every 550 feet in height above the sea.

COMPARISON OF THERMOMETER SCALES.

Centigrade.	Reaumur.	Fahrenheit.	Centigrade.	Reaumur.	Fahrenheit.	Centigrade.	Reaumur.	Fahrenheit.
-30	-24.0	-22.0	14	11.2	57.2	58	46.4	136.4
-28	-22.4	-18.4	16	12.8	60.8	60	48.0	140.0
-26	-20.8	-14.8	18	14.4	64.4	62	49.6	143.6
-24	-19.2	-11.2	20	16.0	68.0	64	51.2	147.2
-22	-17.6	-7.6	22	17.6	71.6	66	52.8	150.8
-20	-16.0	-4.0	24	19.2	75.2	68	54.4	154.4
-18	-14.4	-0.4	26	20.8	78.8	70	56.0	158.0
-16	-12.8	3.2	28	22.4	82.4	72	57.6	161.6
-14	-11.2	6.8	30	24.0	86.0	74	59.2	165.2
-12	-9.6	10.4	32	25.6	89.6	76	60.8	168.8
-10	-8.0	14.0	34	27.2	93.2	78	62.4	172.4
-8	-6.4	17.6	36	28.8	96.8	80	64.0	176.0
-6	-4.8	21.2	38	30.4	100.4	82	65.6	179.6
-4	-3.2	24.8	40	32.0	104.0	84	67.2	183.2
-2	-1.6	28.4	42	33.6	107.6	86	68.8	186.8
0	0.0	32.0	44	35.2	111.2	88	70.4	190.4
2	1.6	35.6	46	36.8	114.8	90	72.0	194.0
4	3.2	39.2	48	38.4	118.4	92	73.6	197.6
6	4.8	42.8	50	40.0	122.0	94	75.2	201.2
8	6.4	46.4	52	41.6	125.6	96	76.8	204.8
10	8.0	50.0	54	43.2	129.2	98	78.4	208.4
12	9.6	53.6	56	44.8	132.8	100	80.0	212.0

Temperature of Fire.—The following table, from M. Pouillet, will enable the temperature to be judged by the appearance of the fire:

Appearance.	Temp. Fahrenheit.	Appearance.	Temp. Fahrenheit.
Orange, deep. ..	2010 degrees.	Red, just visible.	977 degrees.
" clear....	2190 "	" dull	1290 "
White heat.	2370 "	" Cherry, dull.	1470 "
" bright....	2550 "	" " full.	1650 "
" dazzling .	2730 "	" " clear	1830 "

To determine temperature by **fusion of metals**, etc.:

Substance.	Temp. Fah.	Metal.	Temp. Fah.	Metal.	Temp. Fah.
Tallow......	92	Bismuth	518	Silver, pure......	1830
Spermaceti.	120	Lead	630	Gold Coin,........	2156
Wax, white.......	154	Zinc	793	Iron Cast, med..	2010
Sulphur..	239	Antimony	810	Steel	2550
Tin..............	455	Brace...........	1650	Wrought Iron...	2910

Temperature of Compressed Air.—

Before Compress	Pressure and Resulting Temperature in Degrees							
	15	30	45	60	75	90	105	120
60°	177	255	317	369	416	455	490	522
90°	212	294	362	417	465	507	545	580

Temperature of Ignition.—See Ignition.

Temperature of Smoke Box.—See Smoke Box Temperature.

Ten-Wheeler.—Locomotive with full truck and 6 coupled drivers.

Tensile Strength.—Strength to resist a direct pull. Given as force required to pull in two, a bar containing one square inch of material.

Terminal Pressure.—Pressure at end of the stroke. In a multiple expansion engine the terminal pressure of the first cylinder is the initial pressure of the next, and so on through them all.

Three Cylinder Compound—Webb.—Designed and used by Webb, of the London and North-Western R. R. Two high pressure cylinders outside, connected to second pair of drivers and one large low pressure cylinder under smoke arch connecting to cranked axle of the forward drivers. No side rods. Both high pressure cylinders exhaust into the one low pressure. Have done very good work.

Ties.—Burnettized. A method of pressing timber by the use of zinc chloride. Invented by Burnett and largely used in Russia. Costs about 3¾ cts. per foot.

Ties.—Creosoted. Probably the most effective preservative for timber. Also most expensive. Cost of zinc creosote treatment is about 7½ cents per cu. ft.

Ties.—Kyanized. A method of treating timber to preserve it. Invented by Kyan and largely used in Europe. Introduced in America in 1838, but never largely used here. It employs bi-chloride of mercury or corrosive sublimate.

Ties.—Willhouse Treatment. Consists of injections of zinc chloride followed by solutions of glue and tannin. The latter make an artifical leather and plug up the ducts. Results are said to be very satisfactory.

Ties.—Definition of Terms. Investigation of this subject shows that there are wide differences in the terms applicable to the various kinds of ties and their conditions. The definitions here given represent what the committee believes to be the best and most general usage.

Doty Tie.—A tie which contains dote or dry rot.

Heart Tie.—A tie which shows sap wood only on the corners and which sap wood does not measure more than 1 inch on lines drawn diagonally across end of tie.

Pecky Tie.—A tie made from a cypress tree which is affected with a fungus disease, known locally as peck. This does not necessarily affect the usefulness of the tie.

Pole Tie.—A tie made from a tree of such size not more than one tie can be made from

a section. Such a tie generally shows sap wood on two sides.

Quartered Tie.—A tie made from a tree of such size that not more than four ties can be made from a section.

Slab Tie.—A tie hewn or sown on top and bottom only.

Sap Tie.—A tie which shows more than a prescribed amount of sap wood in cross section.

Score Marks.—Marks made by the ax as a guide for hewing.

Split Tie.—A tie made from a tree of such size that not more than two ties can be made from a section.

Strict Heart Tie.—A tie which shows no sap wood in cross section.

Tapped Tie.—A tie made from a tree, the resin or turpentine of which has been extracted before felling.

Tie Plate.—Something interposed between the rail and the tie to prevent wear of the tie.

Wave Tie.—A tie which has a bend or crook in its length.

Wind Shake.—A defect in timber caused by action of wind on the growing tree, resulting in the distortion or separation of the fibers.—M. of Way Asso.

Ties.—Life of. The A. T. & S. F. Ry., with an experience extending over seventeen years, shows an average life for inferior pines and spruces treated with zinc chloride, of eleven years. The Atlantic system of the Southern Pacific Railroad, with the same number of years' experience, shows a life of sap pine ties treated with the same material of nine and one-half years, while the Pacific

system of the same road where treated ties have been used for ten years report 57 per cent. of the ties laid in track in 1895 as being in service after eight years. The Pennsylvania Railroad in a test instituted in Indiana in 1892, where burnettized hemlock and untreated white oak laid in rock ballast, show an average life to date of 10.58 years for the first and 10.17 years for the second, with a per cent. of the hemlock and 33 per cent. of the oak still in service. With burnettized tamarack, an average life of 8.84 years and of untreated white oak 9.47 years, both laid in gravel ballast and with now all of the ties removed, has been secured.

Ties per Mile of Single Track.—

18	inches	from	center	to	center....3,520	ties
20	"	"	"		" 3,168	"
22	"	"	"		" 2,889	"
22.5	"	"	"		" 2,816	"
24	"	"	"		" 2,640	"
25.7	"	"	"		" 2,464	"
27	"	"	"		" 2,347	"
30	"	"	"		" 2,112	"
33	"	"	"		" 1,920	"
36	"	"	"		" 1,760	"

Ties.—Average 8 to 9 feet long, should have at least 6-inch face for pole ties and 8-inch face for rectangular ties. Oak ties average from 140 to 185 pounds in weight, and give about 5 years' service. Yellow pine 4 to 5 years' natural and from 12 to 15 years treated with zinc. Cedar is most durable—15 to 20 years. Chestnut lasts about 8 years, and holds spikes well. Redwood is soft, but heavy, and lasts from 10 to 14 years. Fir should be seasoned, and lasts 6 or 7 years in ground. Tie plates increase life of any tie.

"Tippett" Attachment.—A device used with Detroit lubricator to insure regular delivery of oil to valves and cylinders.

Tire Boring.—Ten tires in 4 2-3 hours on Niles Tire Mill. One mechanic and three helpers. Total cost $4.07 or 41 cents per tire, 1904. N. & W. Ry., Roanoke, Va.

Union Pacific, at Omaha. One pair 56-inch flanged tire in 1 hour 45 minutes. Tires bored for 30 cents each.

Tire Turning.—Ten pairs locomotive tires were turned in 9 hours and 6 minutes on a new Niles 90-inch driving wheel lathe at the West Albany shops of the N. Y. C. & H. R. R. R. on Dec. 19, 1905. Fed across tire in 9 revolutions on roughing cut.

Tires.—Recommended of M. M. Asso. The results obtained justify the members of the committee in concluding that it is desirable to have flange tires on all the drivers of mogul, ten-wheel and consolidation engines. With mogul and ten-wheel engines the tires should be set so that the distance between the backs of flanges will be 53¼ inches. With consolidation engines the tires on front and back pairs of wheels should be set so that the distance between backs of flanges will be 53⅛ inches; with the other two pair of drivers the tires should be set so that the distance between backs of flanges will be 53¼ inches.

It should be understood that the committee assumes that the engines will have swinging trucks.

The members of the committee desire to express their thanks for the use of the dynamometer car, which was kindly furnished by the Erie Railroad.

S. HIGGINS, Chairman.

South Bethlehem, Pa., May 2, 1900.

TABLE OF WEIGHT OF FLANGED TIRES.

Diam. of Wheel Center.	3 Inches Thick.		3½ Inches Thick.		4 Inches Thick.		Diam. of Wheel Center.	3 Inches Thick.		3½ Inches Thick.		4 Inches Thick.	
	5½ ins. Wide.	5¾ ins. Wide.	5½ ins. Wide.	5¾ ins. Wide.	5½ ins. Wide.	5¾ ins. Wide.		5½ ins. Wide.	5¾ ins. Wide.	5½ ins. Wide.	5¾ ins. Wide.	5½ ins. Wide.	5¾ ins. Wide.
21	401	417	469	489	540	562	53	936	974	1083	1127	1231	1282
22	418	435	489	508	562	585	64	953	991	1102	1147	1253	1304
23	435	452	508	528	583	607	55	970	1009	1121	1166	1274	1327
24	451	470	527	548	605	630	56	986	1026	1140	1186	1296	1349
25	468	487	546	568	626	652	57	1003	1043	1159	1206	1318	1372
26	485	504	565	588	648	675	58	1020	1060	1178	1226	1339	1394
27	502	522	584	608	670	697	59	1037	1078	1198	1246	1361	1417
28	518	539	604	628	691	720	60	1053	1096	1217	1266	1382	1439
29	535	556	623	648	713	742	61	1070	1113	1236	1286	1404	1462
30	551	574	642	668	734	765	62	1087	1130	1255	1306	1426	1484
31	568	591	661	688	756	787	63	1104	1148	1274	1326	1447	1507
32	585	609	680	708	778	810	64	1120	1165	1293	1346	1469	1529
33	602	626	699	728	799	832	65	1137	1183	1312	1366	1490	1552
34	619	643	718	748	821	855	66	1154	1200	1332	1386	1512	1574
35	635	661	738	768	842	877	67	1170	1217	1351	1406	1534	1597
36	652	678	757	788	864	900	68	1187	1235	1370	1426	1555	1619
37	669	696	776	808	886	922	69	1204	1252	1389	1446	1577	1642
38	686	713	795	828	907	945	70	1221	1269	1408	1466	1598	1664
39	702	730	814	847	929	967	71	1237	1287	1427	1486	1620	1687
40	719	748	833	867	950	990	72	1254	1304	1447	1505	1642	1709
41	736	765	853	887	972	1012	73	1271	1322	1466	1525	1663	1732
42	752	783	872	907	994	1035	74	1287	1339	1485	1545	1685	1754
43	769	800	891	927	1015	1057	75	1304	1356	1504	1565	1706	1777
44	786	817	910	947	1037	1080	76	1321	1374	1523	1585	1728	1799
45	803	835	929	967	1058	1102	77	1338	1391	1542	1605	1750	1822
46	819	852	948	987	1080	1125	78	1354	1409	1562	1625	1771	1844
47	836	870	968	1007	1102	1147	79	1371	1426	1581	1644	1793	1867
48	853	887	987	1027	1123	1169	80	1387	1444	1601	1664	1814	1889
49	869	904	1006	1047	1145	1192	81	1404	1462	1620	1684	1836	1901
50	886	922	1025	1067	1166	1214	82	1420	1479	1639	1704	1857	1924
51	903	939	1044	1087	1188	1237	83	1437	1497	1659	1723	1879	1946
52	920	956	1063	1107	1210	1259	84	1454	1514	1678	1743	1900	1968

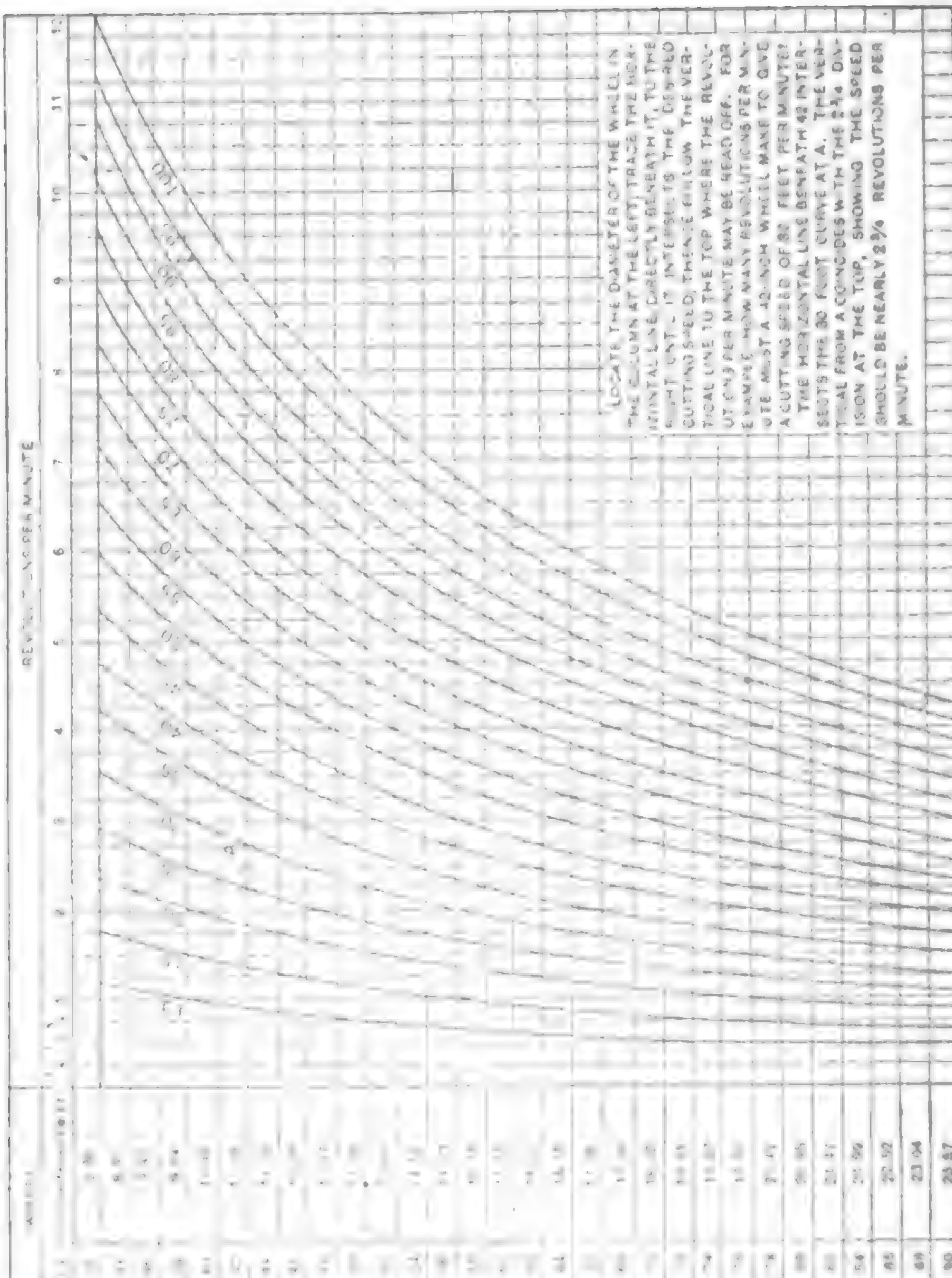
TABLE OF WEIGHT OF PLAIN TIRES.

Diam. of Wheel Center.	3 Inches Thick.		3½ Inches Thick.		4 Inches Thick.		Diam. of Wheel Center	3 Inches Thick.		3½ Inches Thick.		4 Inches Thick.	
	6 Ins. Wide	6½ Ins. Wide	6 Ins. Wide	6½ Ins. Wide	6 Ins. Wide.	6½ Ins. Wide		6 Ins. Wide.	6½ Ins. Wide.	6 Ins. Wide	6½ Ins. Wide	6 Ins. Wide	6½ Ins. Wide.
21	413	446	487	526	563	609	53	963	1040	1122	1212	1283	1388
22	430	464	506	547	585	633	54	980	1059	1142	1234	1306	1412
23	447	483	526	569	608	657	55	997	1078	1162	1255	1328	1437
24	464	502	546	590	630	682	56	1014	1096	1182	1277	1351	1461
25	481	520	566	612	653	706	57	1031	1115	1202	1298	1373	1485
26	499	539	586	633	675	731	58	1049	1133	1221	1320	1396	1510
27	516	557	606	655	698	755	59	1066	1152	1241	1341	1418	1534
28	533	576	626	676	720	779	60	1083	1171	1261	1363	1441	1558
29	550	595	645	697	743	804	61	1100	1189	1281	1384	1463	1583
30	567	613	665	719	765	828	62	1117	1208	1301	1406	1486	1607
31	584	632	685	740	788	852	63	1135	1226	1321	1427	1508	1631
32	602	650	705	762	810	877	64	1152	1245	1341	1449	1531	1656
33	619	669	725	783	833	901	65	1169	1263	1360	1470	1553	1680
34	636	687	745	805	855	925	66	1186	1282	1380	1491	1576	1705
35	653	706	765	826	878	950	67	1203	1301	1400	1513	1598	1729
36	670	726	784	648	900	974	68	1220	1319	1420	1534	1621	1753
37	688	743	804	869	923	998	69	1238	1338	1440	1556	1643	1778
38	705	762	824	891	945	1023	70	1255	1356	1460	1577	1666	1802
39	722	780	844	912	968	1047	71	1272	1375	1480	1599	1688	1826
40	739	799	864	934	990	1071	72	1289	1394	1499	1620	1711	1851
41	756	818	884	955	1013	1096	73	1306	1412	1519	1642	1733	1875
42	774	836	904	976	1035	1120	74	1324	1431	1539	1663	1756	1899
43	791	855	923	998	1058	1144	75	1341	1449	1559	1685	1778	1925
44	808	873	943	1019	1080	1169	76	1358	1468	1579	1706	1801	1948
45	825	892	963	1041	1103	1193	77	1375	1486	1599	1728	1823	1972
46	842	910	983	1062	1126	1218	78	1392	1505	1619	1749	1846	1997
47	860	929	1003	1084	1148	1242	79	1410	1523	1638	1771	1868	2003
48	877	948	1023	1105	1171	1266	80	1427	1542	1658	1792	1891	2027
49	894	966	1043	1127	1193	1291	81	1444	1560	1678	1814	1913	2051
50	911	985	1063	1148	1216	1315	82	1461	1579	1698	1835	1936	2076
51	928	1003	1082	1170	1238	1339	83	1479	1597	1717	1857	1958	2100
52	945	1022	1102	1191	1261	1364	84	1496	1616	1737	1878	1981	2124

PROPER ALLOWANCE FOR SHRINKAGE OF TIRES.

Diameter of Wheel Center	Inside Diameter of Tire.	Allowance for Shrinkage.	Diameter of Wheel Center.	Inside Diameter of Tire.	Allowance for Shrinkage.
20	19.979	.021	53	52.945	.055
21	20.978	.022	54	53.944	.056
22	21.977	.023	55	54.943	.057
23	22.976	.024	56	55.942	.058
24	23.975	.025	57	56.941	.059
25	24.974	.026	58	57.940	.060
26	25.973	.027	59	58.939	.061
27	26.972	.028	60	59.937	.063
28	27.971	.029	61	60.936	.064
29	28.970	.030	62	61.935	.065
30	29.969	.031	63	62.934	.066
31	30.968	.032	64	63.933	.067
32	31.967	.033	65	64.932	.068
33	32.966	.034	66	65.931	.069
34	33.965	.035	67	66.930	.070
35	34.964	.036	68	67.929	.071
36	35.962	.038	69	68.928	.072
37	36.961	.039	70	69.927	.073
38	37.960	.040	71	70.926	.074
39	38.959	.041	72	71.925	.075
40	39.958	.042	73	72.924	.076
41	40.957	.043	74	73.923	.077
42	41.956	.044	75	74.922	.078
43	42.955	.045	76	75.921	.079
44	43.954	.046	77	76.920	.080
45	44.953	.047	78	77.919	.081
46	45.952	.048	79	78.918	.082
47	46.951	.049	80	79.917	.083
48	47.950	.050	81	80.916	.084
49	48.949	.051	82	81.915	.085
50	49.948	.052	83	82.914	.086
51	50.947	.053	84	83.912	.088
52	51.946	.054			

Tire Turning Chart.



Tire Wear.—Electric locomotive (weight 320,000 lbs.) on the B. & O. at Baltimore. 42″ wheels —1-16″ per 7,500 miles.

Mallet articulated—No. 2,400, weight 479,500 lbs.—57″ wheels—wear 1-16″ per 15,000 miles with very even wear.

Ton mile.—One ton hauled one mile. A thousand ton-miles is one ton hauled 1000 miles or 1000 tons hauled one mile, or any combination of tons and miles whose product is 1000. Ten tons 100 miles, 25 tons 40 miles or 40 tons 25 miles.

Tonnage rating.—The making up of trains on a tonnage basis instead of by number of cars. Where a large proportion of the train is made up of empty cars the rating is reduced owing to increased car friction per ton of train. This allowance some times reaches 20 per cent.

Top trunk plank.—See trunk bolster.

Torpedo.—An explosive signal which is fastened to rail and set off by train passing over it. Used in foggy weather to warn approaching trains that a train has stopped ahead.

Total Heat of Water.—At atmospheric pressure this is 180.9 heat units. It is the total heat above 32 degrees Fahr., or freezing.

Total Heat of Steam.—The heat units in the water plus the latent heat. At atmospheric pressure this is 180.9×965.7=1146.6 degrees and steam at atmospheric pressure is not often used so that corrections are necessary for various cases. With temperature of feed

water 100 degrees. 30 pounds of water evaporated into steam at 70 pounds pressure is a rated horse power.

To find the evaporation for any case: Subtract the heat units in one pound of feed water from the heat units in one pound of the steam, and divide this by 966. Multiply this by the weight of water evaporated, and the result is the "equivalent evaporation."

Suppose a boiler evaporates 1,500 pounds of water per hour from a feed temperature of 80 degrees into steam at 100 pounds—what is the "equivalent evaporation" and what horse power is the boiler?

We find the feed water contains 48.04 heat units and the steam 1185 heat units. Subtracting 48.04 from 1185, we have 1185—48.04= 1136.96. Dividing it by 966 gives 1.17. This 1.17 is called the factor of evaporation, and means that the equivalent evaporation is 1.17 times the actual.

Multiplying 1,500 by 1.17 gives 1,755 pounds evaporated from and at 212 "degrees." Dividing this by 34½ gives 50.87 horse power.

Track.—Maintenance of way varies from $344 to $1,463 per mile of road, and from 6.5 to 21.7 per cent. of the operating expenses. When the cost of maintaing structures is added to this it becomes $475 to $3,264 per mile.

Tie renewals average from 250 to 300 ties per mile of main line track, and 200 to 250 per mile for side tracks. This without tie plates or preservatives.

Ties treated with preservative are given as follows:

	Untreated.	Treated
Average life—years.....	6	12
Average cost—cents.....	.50	.90
Total cost per tie per year, including interest, etc.	9.7	9.2

In addition to this, there is a better average roadbed than where the roadbed must be renewed oftener.

Rails (30 foot) expand about 7-16 inch from 20 to 140 Fahr.

Track Gage is defined by the Amer. Ry. Engr. and Maint. of Way Assoc. as "the distance measured between the sides of rails ⅝ of an inch between top of head."

Track Tanks.—These are shallow steel tanks of about 3-16 steel, 19 inches wide, 7 inches deep and from 1,200 to 1,500 feet long. The upper edges are stiffened by half-round iron. The scoop is lowered into tank about 3 inches. Tanks are generally placed 25 to 35 miles apart. The system was invented by J. Ramsbotham, in England, in 1861.

Tractive Power.—The force a locomotive exerts horizontally in drawing its load due to the steam pressure acting on the pistons in the cylinders. It depends on the dimensions of cylinders, of drivers and steam pressure, also weight on drivers. It is usually calculated so as to be about ¼ of the adhesion.

Tractive Power:—Simple locomotives. Square cylinder diameter, multiply by length of stroke in inches and by mean effective pressure—divide this by diameter of drivers in inches

Take pressure as 85 per cent. boiler pressure at starting a train. Or use the following formula:

$$\text{Tractive power} = \frac{C^2 \times S \times P}{D} \text{ in which}$$

C^2=diameter of cylinder multiplied by itself.

S =stroke of piston in inches.

P =mean effective pressure in pounds taken at 85 per cent. of boiled pressure.

D =diameter of driving wheel in inches. In other words, we first multiply the cylinder diameter by itself, then by the length of stroke in inches and by the mean effective pressure. Divide all this by the diameter of drivers in inches.

Example.—Cylinders 20 × 26 — Boiler pressure 200 — drivers 60 inches. 20 × 20 = 400. 26 × 400 = 10400. 85 per cent of 200 = 170. 10400 × 170 = 1,768,000. Dividing this by 60 gives 29,466 pounds of tractive power.

Tractive Power.—Rules for Baldwin 4-cylinder compound.

$$\text{Tractive power} = \frac{C^2 \times S \times 2\text{-}3\ P}{D} + \frac{C^2 \times S \times \frac{1}{4} P}{D}$$

C^2=diameter of high pressure cylinder-squared.

S =stroke of piston in inches.

2-3 P = two-thirds boiler pressure.

D =diameter of drivers in inches.

C^2 = diameter of low pressure cylinder-squared.

S = stroke of piston in inches.

¼ P=one-quarter boiler pressure.

D =diameter of drivers.

Tractive power.—Rule for 2 cylinder compound.

$$\text{Tractive power} = \frac{C^2 \times S \times 2\text{-}3\ P}{D} \text{ where}$$

C^2=diameter of high pressure cylinder.

S =stroke of piston in inches.

2-3 P=two-thirds of boiler pressure.

D =diameter of drivers.

Track definitions.—

Alignment: The location of the road with reference to curves and tangents.

Curve: A series of changes in direction according to a regular method.

Curve Easement: A curve of regularly varying radii, connecting a tangent to simple curve, or connecting two simple curves.

Curve, Simple: A series of uniform changes in direction according to a fixed method.

Curve, Vertical: A curve used to connect intersecting grade lines.

Elevation (as applied to curves): The amount which the outer rail is raised above the inner rail.

Gauge (of track): The shortest distance between the inside of the heads of the two rails forming the track, the same to be measured between parallel surfaces, perpendicular to the plane through tops of the two rails, and projecting 1⅝ inches below the plane.

Gauge, Standard: The gauge of 4 feet 8½ inches.

Gauge (Track Tool—Standard Specifications): The gauge recommended shall be a wooden bar with parallel metal measuring surfaces fastened rigidly to it. These measuring surfaces shall be perpendicular to plane of top of rails and shall extend to a depth of 1⅝ inches below same.

Level: The condition of the track as to the equal elevation of the rails transversely.

Line: The condition of the track in regard to uniformity in direction over short dis-

tances on tangents, or uniformity in variation in direction over short distances on curves.

Surface: The condition of the track as to vertical evenness or smoothness over short distances.

Tangent: Straight track.

Track: Ties, rails and fastenings, with all parts in their proper relative places.

Traction Increaser.—A device for transfering a portion of the weight of locomotive from truck or trailing wheels, or both, to drivers so as temporarily increase adhesion. Used in starting or on bad hills where there is a tendency to slip. Was patented by Ross Winans, in 1851, and has been used in various ways since, mostly on engines with a single pair of drivers or the Atlantic type. The modern way is to use an air cylinder to change the fulcrum on the equalizers.

Wilson Eddy, of the Boston & Albany, made a toggle arrangement so that the weight of tank was transfered to engine. The harder the engine pulled the more the tender was lifted.

Train-Mile.—One train hauled one mile. Less accurate than either car-mile or ton-mile. See latter for details.

Train resistance.—The resistance that must be overcome to move train. Depends on load, friction of bearings and track. Is always calculated in pounds per ton, meaning pounds pull necessary to move one ton. This varies from 5 to 12 pounds, with an average of 6½ lbs. for standard cars. For cars with mixed axles and loose wheels, 8 to 12 lbs. Contractor cars up to 40 lbs.

Train resistance.—

$$\frac{\text{Square of Speed}}{171} + 6 = R \text{ in lbs. per ton (2000 lbs.)}$$

$$\text{Speed} = \sqrt{171 \times R - 6}$$

Grade in Ft. per mile $\times$ .3788 = R, due to rise.

Curves = ½ lb. per degree.

Add to resistance of straight, level track.

Transition curve.—See curves.

Transom.—See bolster and body bolster. Bolster is more generally used.

Tread of wheel.—The outside of rim which runs on the rail. The flange is not considered part of the tread.

Train Order Signals.—1905. Where block signal systems are used, when it becomes necessary to issue train orders, the attention of engineman and conductor is called by

1. Same signal as used for blocking on Buffalo, Rochester & Pittsburg Railway.
   Chicago, Burlington & Quincy Railroad.
   Chicago & Northwestern Railway. (Hall Signals will change practice.)
   Lehigh Valley Railroad.
   Mobile & Ohio Railroad.
   Santa Fe System.
   Southern Indiana Railway.
   Southern Pacific Co. (Pac. Sys.)
   Chicago Great Western Railway.
   Delaware, Lackawanna & Western Railroad.
2. Separate train-order signals on
   Central R. R. Co. of New Jersey. (Train order signal has double lenses and block signals single lenses. Also control distant block in rear.)
   Illinois Central Railroad.

Michigan Central Railroad.
Philadelphia & Reading Railway.
Plant System.

3. A red or green flag or lantern on
   Baltimore & Ohio Railroad. (Where automatic blocks are used, train-order signals are also used, controlling first automatic distant signal blade in each direction.)
   Boston & Maine Railroad.
   Delaware, Lackawanna & Western Railroad.
   Erie Railroad.
   Long Island Railroad.
   Pennsylvania Lines west of Pittsburg.

When running on a track in the reverse direction, the engineman and conductor are notified of train orders by

1. Regular train-order signals, where placed for both directions on one mast:
   Chicago, Burlington & Quincy Railroad. (Have telegraph blocks in use on some double track.)
   Chicago & Eastern Illinois Railroad.
   Chicago & Northwestern Railway.
   Delaware, Lackawanna & Western Railroad.
   Galveston, Harrisburg & San Antonio Railroad.
   Illinois Central Railroad.
   Lehigh Valley Railroad.
   Pennsylvania Lines west of Pittsburg.
   Philadelphia & Reading Railway.
   Plant System.
   Southern Pacific Co. (Pac. Sys.)
2. Red flags and hand lamps where train order signals are placed alongside of track on separate masts, on
   Pennsylvania Lines west of Pittsburg.

3. **Red flag and hand lamp in addition to the regular train-order signals, some offices having no train-order signal, on**
   Boston & Maine Railroad.
   Erie Railroad.
   Long Island Railroad.
4. Regular train-order signal, and in addition a red flag or hand lamp set on the track, on
   Boston & Maine Railroad.
   Michigan Central Railroad.
5. Red flags or hand lamps on
   Baltimore & Ohio Railroad.
   Central R. R. Co. of New Jersey.
   Mobile & Ohio Railroad.

Transition Curve.—See Curve, Transition.

Trestle wood.—Terms used.

Batter.—The deviation from a perpendicular in upright members of a bent.

Bent.—The group of members forming a single vertical support of a trestle, designated as pile bent where the principal members are piles, and as framed bent where of framed timbers.

Bulkhead.—Timber placed on edge against the side of an end bent for the purpose of retaining the embankment.

Cap.—The horizontal member upon the tops of piles or post connecting them in the form of a bent.

Dowel.—A short iron or wooden pin used to connect members.

Drift Bolt.—A long piece of round or square iron with or without head or point driven as a spike.

Frame Trestle.—One in which the vertical members or supports are framed timbers.

Guard Rails.—Longitudinal members, either iron or wood, secured on top of ties.

Intermediate Sill.—A horizontal member in the plane of the bent between the cap and lower sill and into which the posts are framed.

Longitudinal Struts or Girts.—Stiff members running horizontally or nearly so from bent to bent.

Longitudinal X Braces.—Members extending diagonally from bent to bent in vertical planes.

Packing Spools or Separators.—Small castings used in connection with packing bolts to hold stringers in relative position.

Pile Trestle.—One in which the vertical members or supports are piles.

Piles. Timbers driven in the ground and intended generally to support a structure.

Posts.—The vertical and battered members of the bent of a framed trestle.

Sash Braces.—Members secured horizontally to the posts or piles of a bent.

Shim.—A block used to raise any portion of a structure (and is generally evidence of faulty construction).

Sill.—The lower horizontal member of a framed bent.

Stringers—The longitudinal members extending from bent to bent and supporting the ties.

Subsills.—Timbers bedded in the ground to support framed bents.

Sway Braces.—Members bolted or spiked to the bent and extending diagonally across its face.

Ties.—Transverse timbers resting on the stringers and supporting the track.

Trestle—Wooden.—A structure composed of vertical members, supporting simple horizontal

members or beams, the whole forming a support for loads applied to the horizontal members. For parts see terms that follow.

Trigger.—The small handle controlling the latch in either reverse lever or throttle lever.

Truck—Bissell.—Patented in 1857. Originally a four wheel truck which turned on a pin at some distance behind the rear axle of truck. Engine rested on a pair of V shaped inclined planes between axles, to center it on straight track. In 1858 he patented two wheel or pony truck on same principles, and this is usually called the Bissell truck. Rogers used it in 1862 on his first "Moguls."

Truck bolster.—That part of truck on which car body rests. See top truck plank, truck log, swing bolster, swing beam, swing log.

Truck log.—See truck bolster.

Trucks—Engine.—Fig. 1.—Two-wheeled or Pony truck. Fig. 2.—Four-wheeled truck.

1. Center pin. 2. Swing bolster. 3. Cross-tie. 4. Link. 5. Truck frame. 6. Pedestal. 7. Cap. 8. Equalizing beam. 9. Spring link. 10. Axle. 11. Wheel. 12. Radius bar. 13. Brace. 14. Longitudinal brace. 15. Spring staple. 16. Spring seat. 17. Safety strap.

Truck, Tender, Wood.—1. Channel bar. 2. Top bar of frame. 3. Truss bar. 4. Bottom bar. 5. Wheel. 6. Side bearing. 7. Frame filling piece. 8. Center plate. 9. Truss plate. 10. Washer. 11. Bolster guide. 12. Spring seat. 13. Brake clevis. 14. Brake beam safety chain.

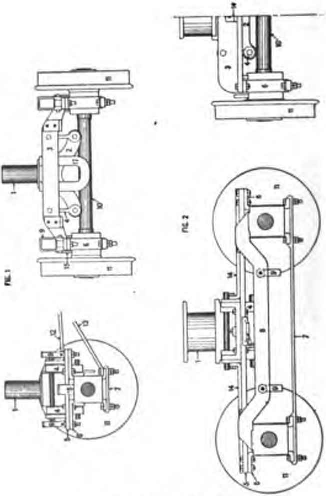
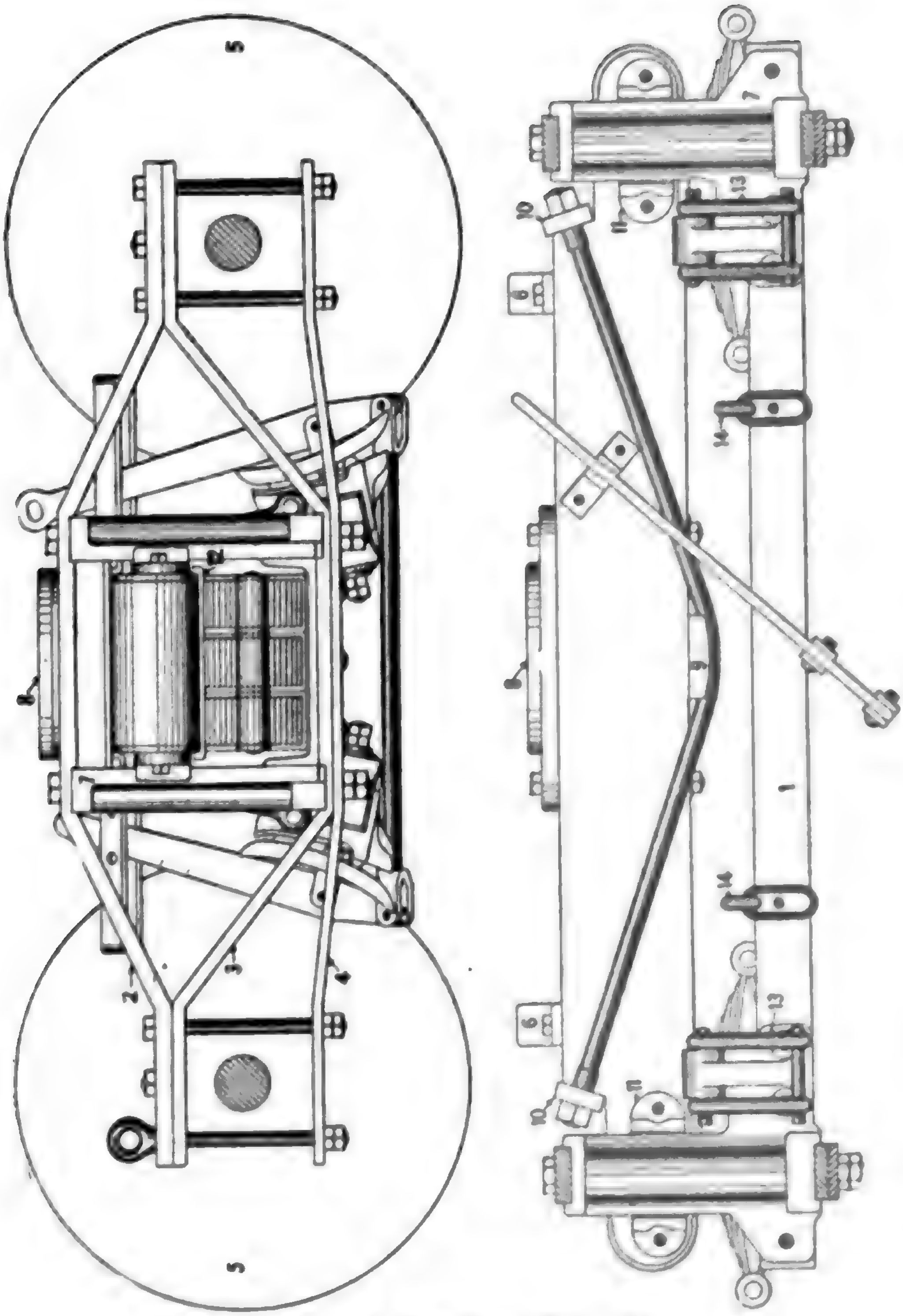


FIG. 1

FIG. 2

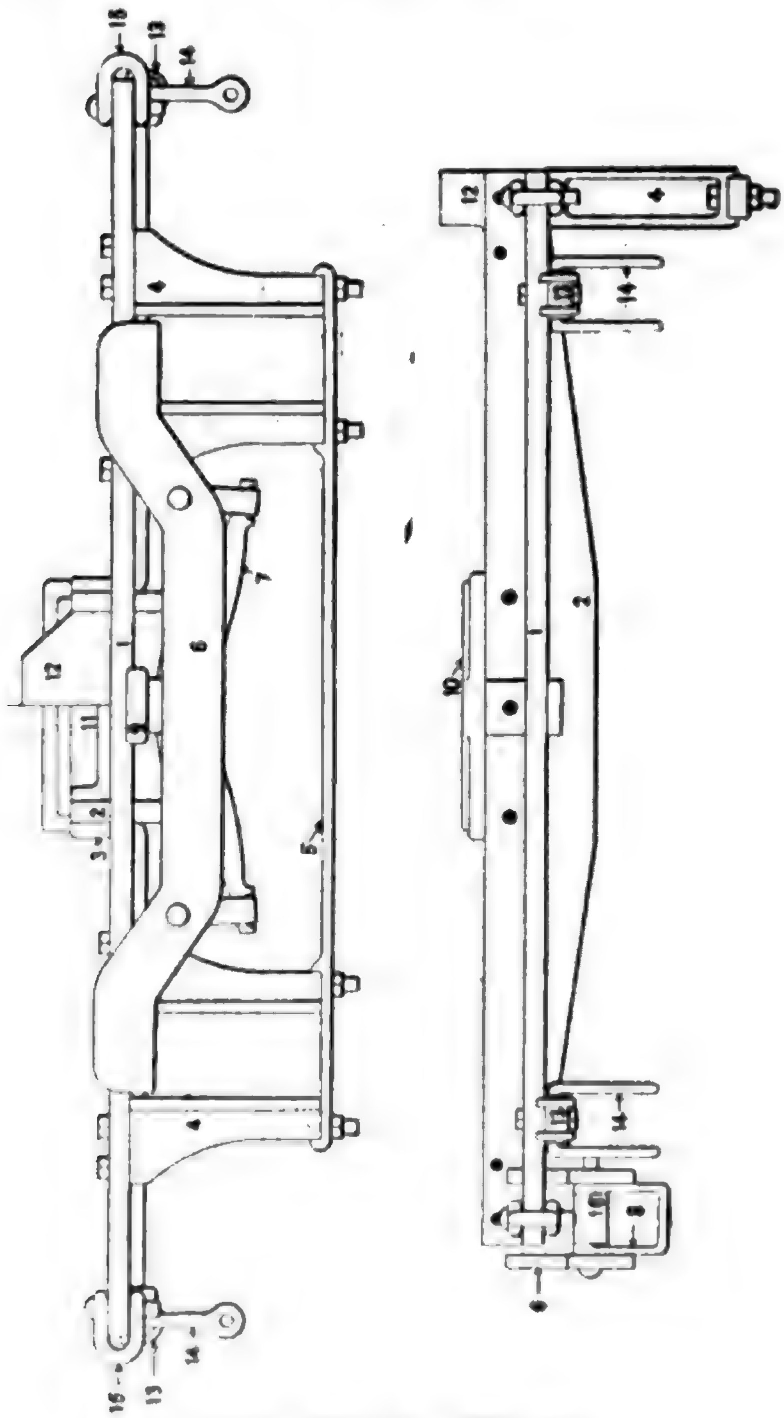
Iron Tender Truck.

T-24



Wood Tender Truck.

Truck, Iron.—1. Frame. 2. Cross tie. 3. Brace. 4. Pedestal. 5. Cap. 6. Equalizing beam. 7. Spring. 8. Link. 9. Spring seat. 10. Center plate. 11. Filling piece. 12. Side bearing. 13. Brake hanger. 14. Clevis. 15. Safety chain clevis. 16. Spring link washer.



Iron Truck Frame.

Truss rod bearing.—Support for car body between truss rod and body. Also called queen posts, truss rod post, truss strut.

Truss rod post.—See truss rod bearing.

Truss rod strut.—See truss rod bearing.

Try-cocks.—Small valves placed on back end of boiler to show height of water in boiler. There are usually three, the lowest about 3 inches above crown sheet, and placed four to five inches apart.

Tubes.—Sometimes called flues. Extend from front sheet of fire box to front end or smoke box. Carry off the heat and gasses and imparts it to water in boiler which surrounds them. See cut of boiler.

Tubes.—Length. This varies from 70 to 90 times the outside diameter. M. M. Reports. 1897.

Tubes.—Serve. The heating surface of the Serve or internally ribbed tube which is used largely in foreign practice, is calculated as the whole interior or fire surface—ribs and all.

Tube Expander.—Tool for expanding tubes in tubes sheets. Most popular are Prosser and Dudgeon.

Tunnels—Swiss.—

Name	Opened	Length of Miles	Yds. Per Day	Cost Per Yd
Mt. Cenis	1871	7½	2.5	$1,130
St. Gothard	1881	9½	6.01	715
Arlberg	1883	6½	9.07	540
Simplon	1905	12½	9.	540

Turntables.—

A comparative statement of costs of various methods of operating turntables by power, prepared for the Association of Railway Superintendents of Bridges and Buildings by Mr. F. E.

Schall, bridge engineer of the Lehigh Valley Railroad, presents interesting figures. He states that equipments for driving turntables by gasoline engines cost about $1,100 and by electric motor (General Electric Company) about $1,150, and that the economy depends upon the number of engines turned, as the following record shows:

[Note.—These figures do not include interest or depreciation, which would amount to about 45 cents per day.]

64-Ft. Turn-Table at Coxton, Pa., 5 H. P. Gasoline Engine, Installed July, 1901.

Average number of engines turned per day of 24 hours in a period of one year, 174.

Average cost per engine turned in a period of one year, 2 21-100 cents.

Average cost of labor and material operating turn-table per day of 24 hours, $3.78.

75-Ft. Diameter Turn-Table at Lehighton, Pa., Operated by 5 H. P. Gasoline Engine, Installed February 12, 1902.

Average number of engines turned per day of 24 hours, 121.

Average cost per engine turned, 2 9-10 cents.

Average cost of labor and material operating turn-table per day of 24 hours, $3.41.

75-Ft. Diameter Turn-Table at South Easton, Pa., Operated by 5 H. P. Gasoline Engine, Installed March 14, 1902.

Average number of engines turned per day of 24 hours, 188.

Average cost per engine turned, 1 97-100 cents.

Average cost of labor and material operating turn-table per day of 24 hours, $3.74.

75-Ft. Diameter Turn-Table at Wilkes-Barre,, Pa., Operated by 5 H. P. Gasoline Engine, Installed March 18, 1902.

Average number of engines turned per day of 24 hours, 46.

Average cost per engine turned, 6 5-10 cents.

Average cost of labor and material operating turn-table per day of 24 hours, $2.91.

75-Ft. Diameter Turn-Table at East Buffalo, N. Y., Operated by 5 H. P. Gasoline Engine, Installed April 1, 1902.

Average number of engines per day of 24 hours, 103.

Average cost per engine turned, 3 37-100 cents.

Average cost of labor and material operating turn-table per day of 24 hours, $3.41.

64-Ft. Turn-Table at Sayre, Pa., Operated by 20 H. P. Electric Motor, Installed June 1, 1902.

Average number of engines turned per day of 24 hours, 109.

Average cost per engine turned, 3 7-10 cents.

Average cost of labor and material operating turn-table per day of 24 hours, $4.01.

American Engineer, 1903.

<u>Two cylinder compound.</u>—See locomotive-compound.

<u>Types of Locomotives.</u>—See locomotives—Types of.

V

Vacuum.—Absence of pressure. In steam engineering the reduction of pressure below the atmosphere on the exhaust side of the piston in condensing engines.

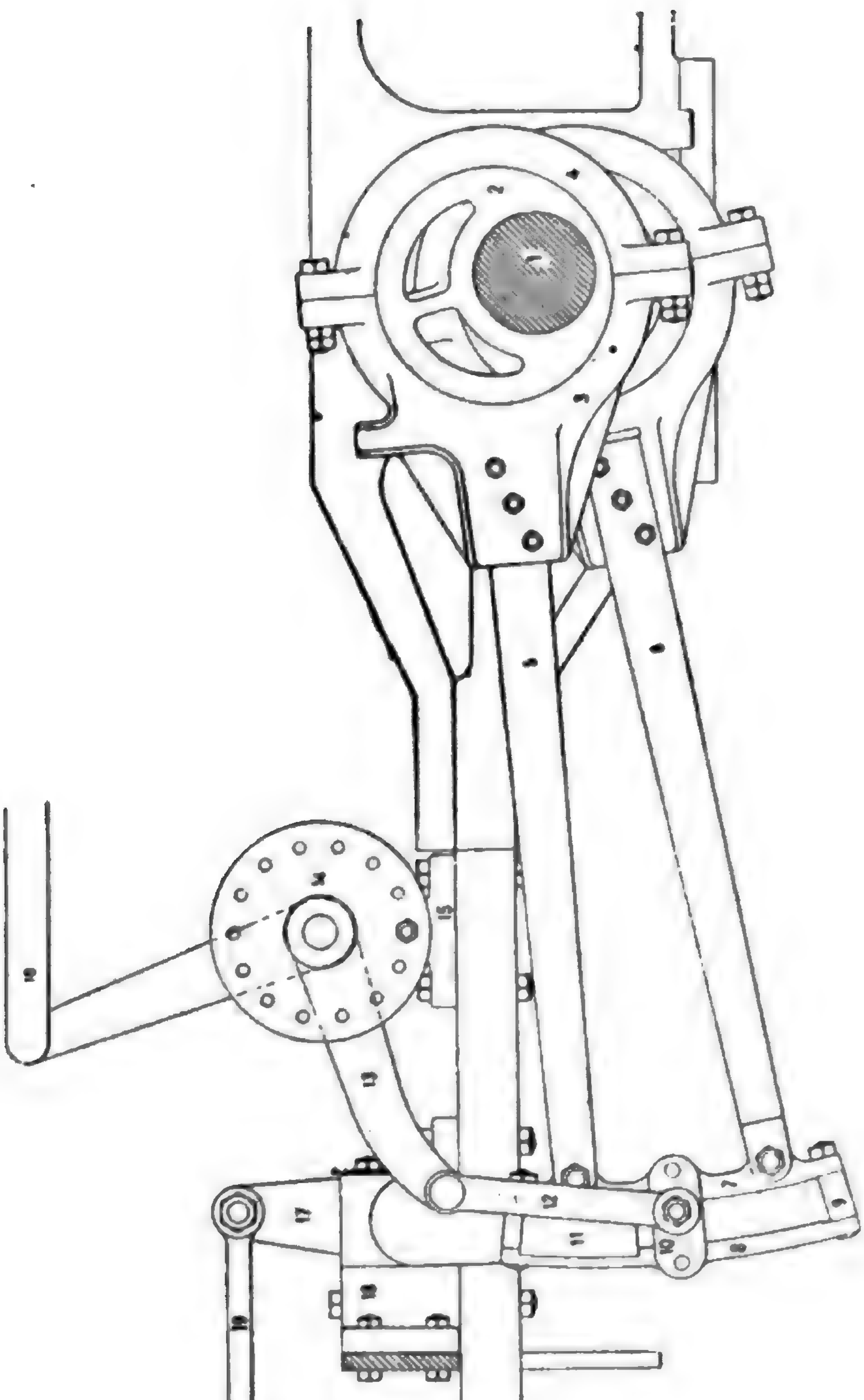
Variable Exhaust.—See Exhaust.

Valves.—Inside or Exhaust Lap. Exhaust lap is a better term than inside lap owing to the introduction of piston valves having steam admission at the center. The meaning is the same in either case of lap. Exhaust lap delays the opening of exhaust port and closes it earlier, making more compression.

Valves.—Lap. Distance which valve over-laps or covers port when valve is in center. Or distance which valve must move from central position before port begins to open. Always applied to lap on steam side of valve unless otherwise stated.

Valve Setting.—Lead. The amount of port opening when piston is at end of its stroke. The distance valve has opened port before piston starts on return stroke.

Valve Setting.—Line and Line. Set so that port has neither lap nor lead. Any further



Valve Motion Work.

movement of valve opens it or closes it still further. In other words valve just closes the port.

Valve Motion Work.—1. Axle. 2. Eccentrics. 3. Eccentric strap, front half. 4. Back half. 5. Eccentric rod, forward motion. 6. Back motion. 7. Reverse link, back half. 8. Front half. 9. Filling piece. 10. Saddle. 11. Block. 12. Link lifter. 13. Reverse shaft. 14. Counter balance spring. 15. Shaft bearing. 16. Reach rod. 17. Rock shaft. 18. Rocker box. 19. Valve rod.

Valve Setting.—Negative Lead Often called "setting blind," and meaning that instead of steam port being open when engine is on the center, the port is closed by a given amount of lap. See "Line and Line."

Vanderbilt tender.—Water is carried in tank like an oil car—round. Coal carried in pockets on corners. Not liked on engines with a short deck or none at all, as there is no room to handle a poker to clean fires.

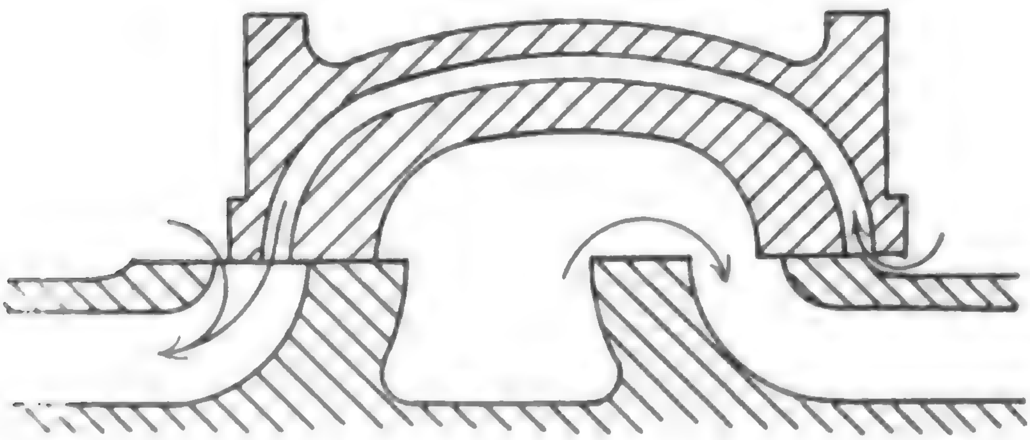
Valve Gear.—See Valve Motion.

Valve Motion.—A name applied to all the mechanism used to move the valve of an engine. That most commonly used is the plain shifting link, often erroneously credited to George Stephenson and Howe.—See link motion.

Valve Motions.—Stephenson (Williams) Link. Walschaert—Gooch—Fink—Waldegg — Joy — Wilson—Lewis Strong. Clark—Stevens. See heading for each.

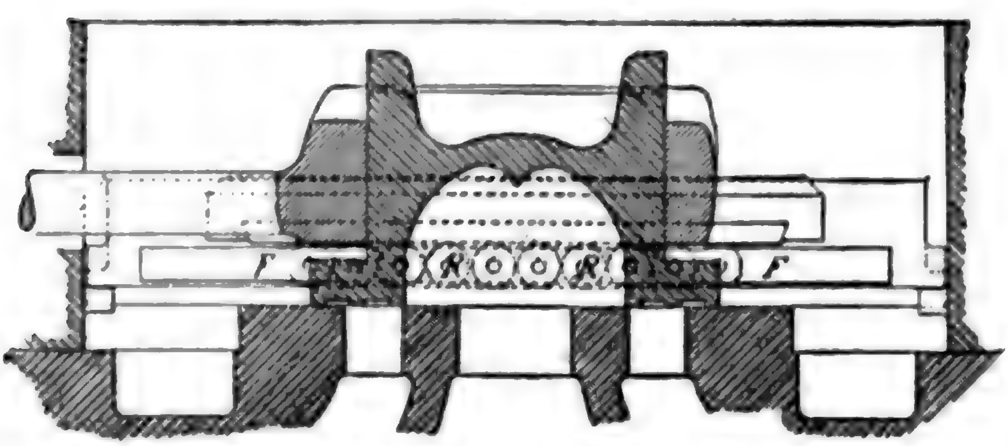
Valve Motion.—Radial. A method of moving the valve by levers from cross head or connecting rod or both instead of from two eccentrics. Among them are the Walschaert, Joy, Wilson, Stevens, Strong and Lewis.

Valve.—Allen. Introduced in 1882 but not largely used until considerably later. Considered especially useful for fast passenger work on account of increased opening.

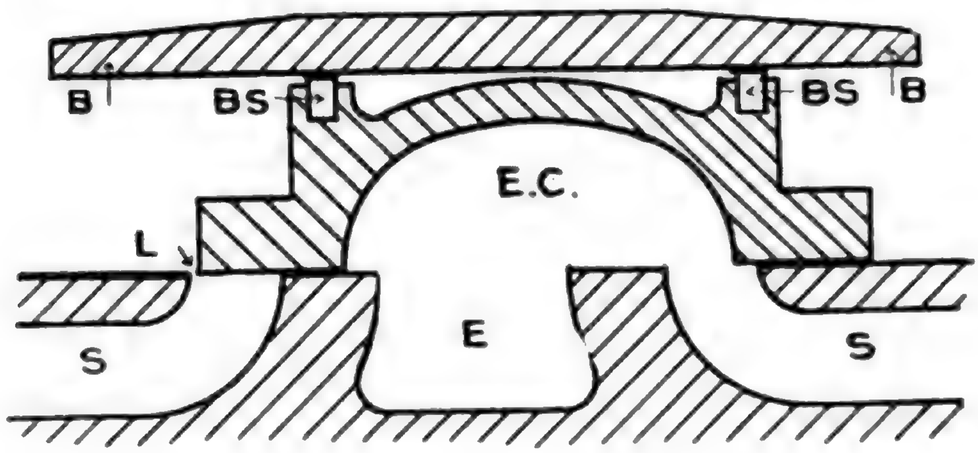


Allen Valve.

Valve.—Bristol Roller. A D valve having steel rollers on each side to carry pressure. Impossible to keep tight. Used about 1868.

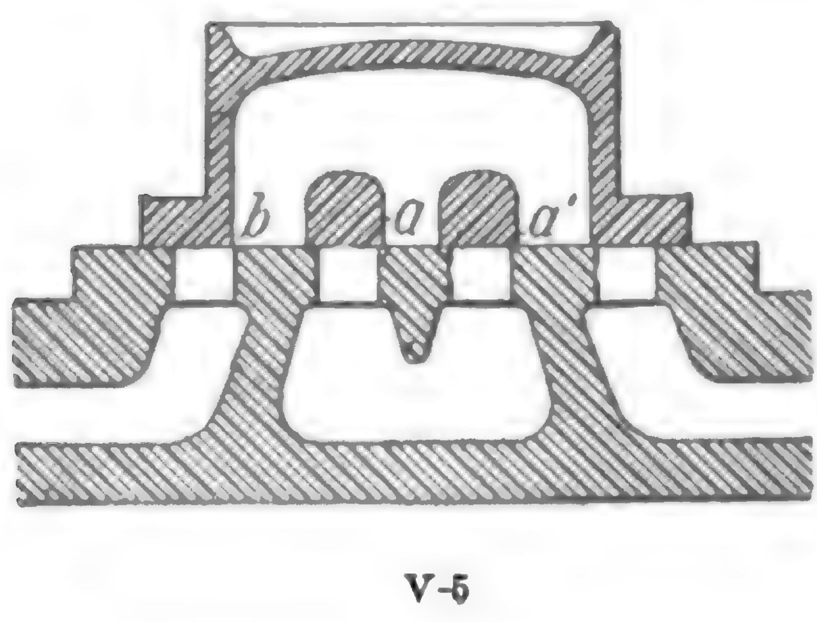


Valve.—Balanced. Slide valve having a balance plate to relieve pressure. BB—Balance plate. BS—Balance strips. SS—Steam ports. E—Exhaust port. EC—Exhaust cavity. L—Lead.

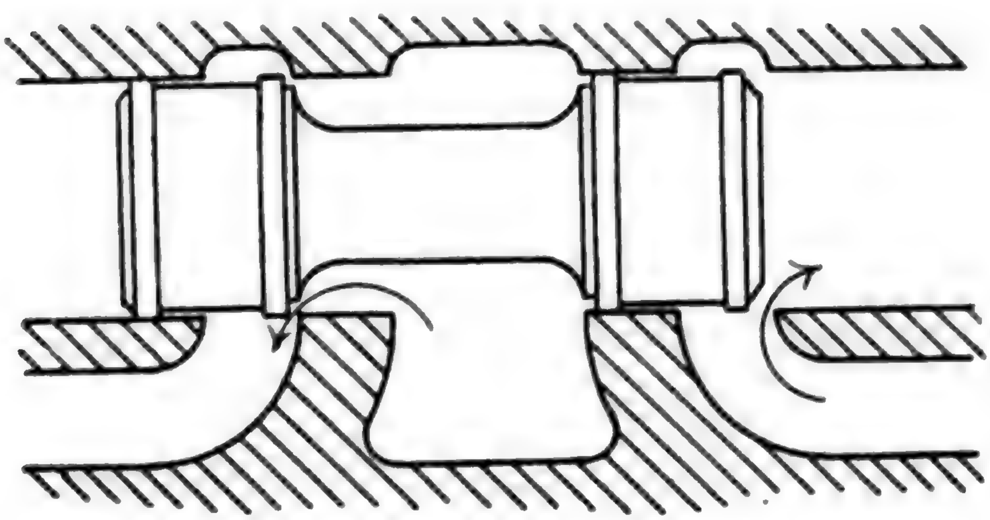


Valve.—"D." Name given the common slide valve, although it hardly forms a letter D. See sketch of Balanced Valve.

Valve.—Hackworth. A "D" valve with double exhaust parts as shown. Sometimes called "cabbage cutters" owing to resemblance of seat to that kitchen utensil. Used largely by Rogers beginning in 1853.



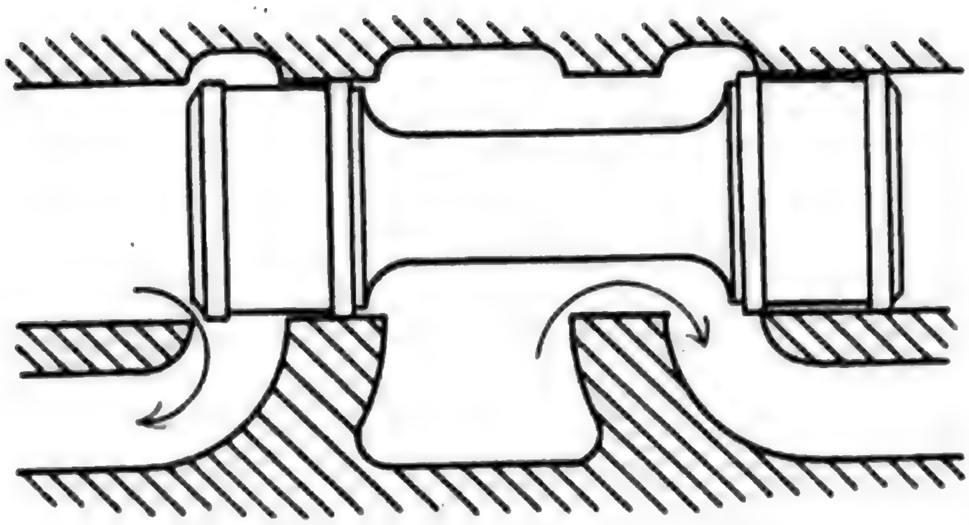
Valve.—Piston. A round or cylindrical valve instead of one having a flat seat as the D valve. Advocated by many on account of being practically balanced by steam pressing equally in both directions. First one probably used on Earl of Airlee, 1831. See Valve —"inside and outside" admission.



Inside Admission Piston Valve.

Valves—Piston with Inside Admission. Admit steam from centre of valve, as shown, instead of end. Most piston valves in use are on this plan. This keeps hottest steam away from cool valve chamber heads, and subjects valve rod-packing to exhaust steam only. See Link Motions.

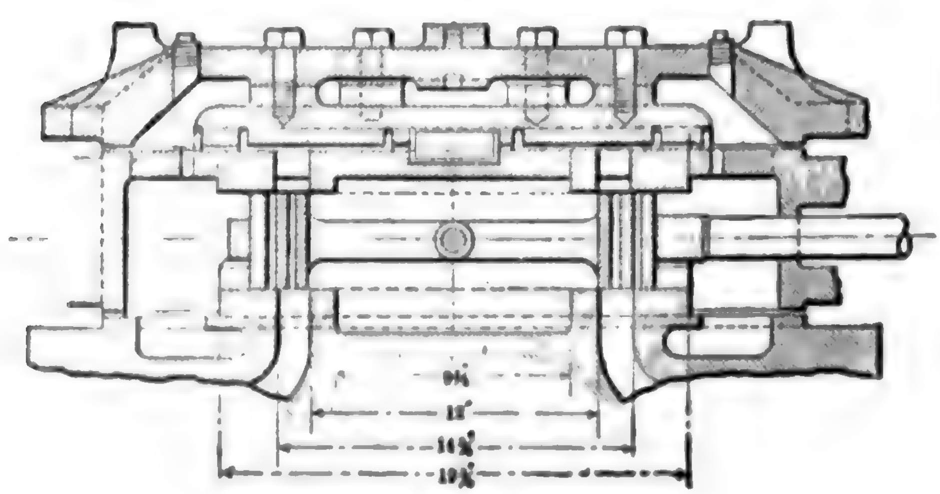
Valves.—Piston. Outside Admission. Admitting steam from outer edges as shown—same as slide valve. Piston Valves of this kind act and are set same as slide valves. See Link Motions.



Outside Admission Piston Valve.

Valve Seat.—Surface on which valve slides or moves, and from which the parts go to cylinder. Seat is short enough to allow valve to over-travel at short cut-offs to avoid wearing ridges at each end of seat.

Valve.—Wilson's American. A novel method of balancing a valve during various portions of its stroke. The balance plate has parts corresponding to those of the valve seat as shown, so that steam pressure is equalized on both sides of valve. Patented in 1901 by H. F. Wilson, Jersey Shore, Pa.



Valves.—Clearance. Sometimes called negative lap, but this is a poor name. The amount that exhaust port is open with valve in center. Corresponds with lead on the steam side and opens exhaust earlier, closing it later.

Valve Gear, Weight of.—

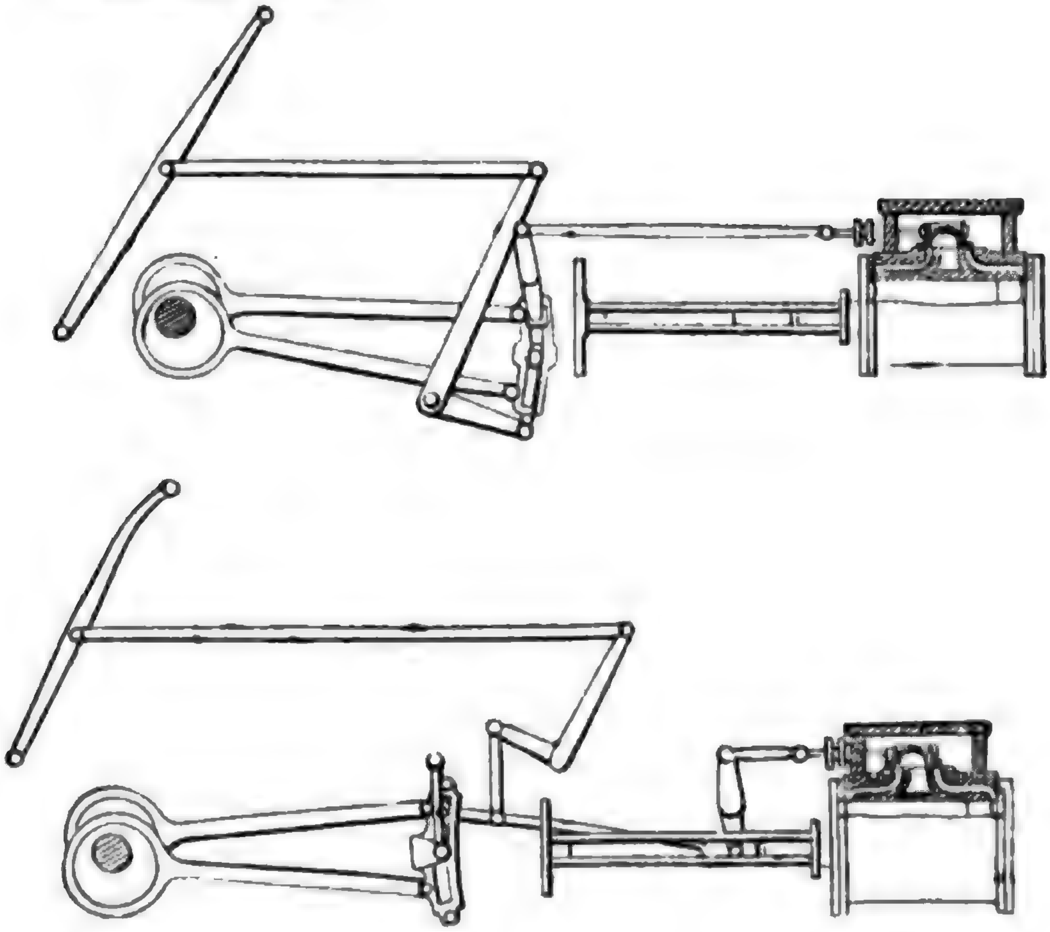
	Consolidation. Link lbs.	Walschaert lbs.
Crank pins, main	520	490
Crank pin arms	...	100
Crosshead arms	...	60
Eccentric	600	...
Eccentric strap	800	...
Eccentric rods	200	220
Link	280	260
Link support	...	280
Link lifter	45	...
Reverse shaft and arms	260	400
Rockers	260	...
Rocker boxes	240	...
Transmission bar	300	140
Transmission bar hanger	80	72
Transmission bar bracket	...	...
Valve rod	80	70
Vibrating rod	...	220
Vibrating link	...	70
Total, lbs.	3,665	2,382

Valves.—Weight of—

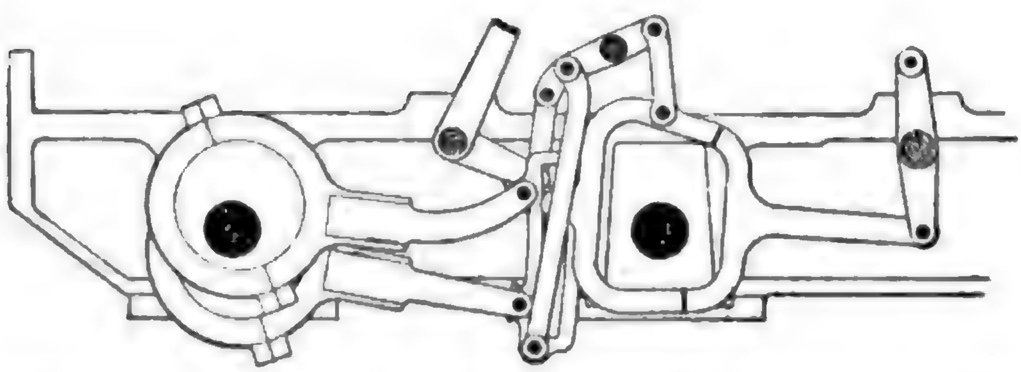
Richardson for	16″ port		100 lbs.
" "	18″ "		125 "
Allen-Richardson	23″ "	(L. P. on Comp.)	205 "
10″ Piston Valves			130 "
11″ " "			160 "
12″ " "			195 "

Richardson Valves have $\frac{1}{16}$″ clearance between valve and pressure plate. H. G. Hammett.

Valve Motions.—

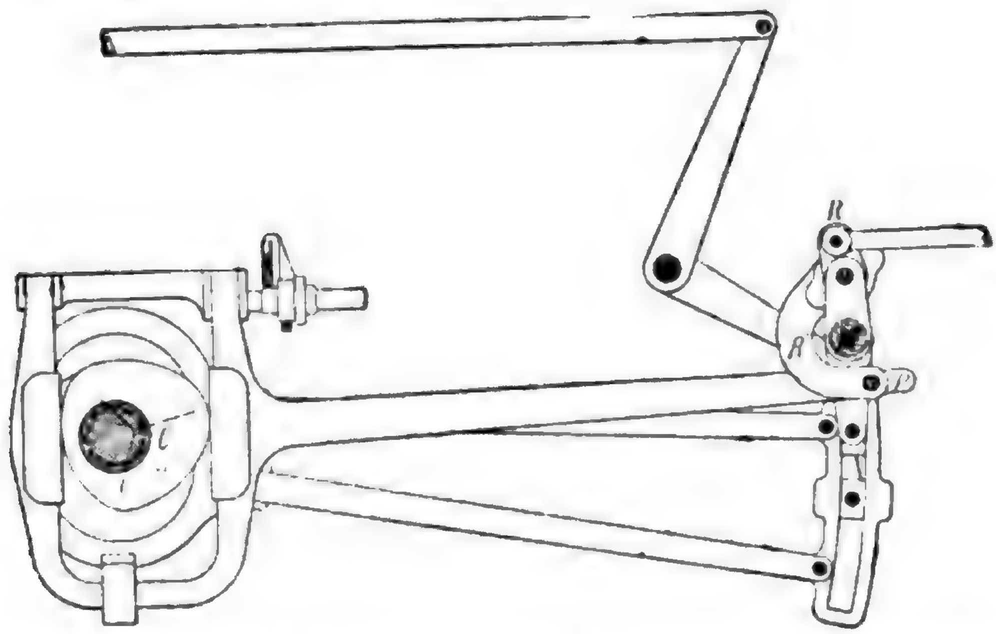


Early Link Motions.—Lower One Stationary Link (Gooch)—Rogers, 1849-1850.



Valve Gear With Transmission Rods to Get Around Axle—Rogers, 1873.

Valve Motions.—

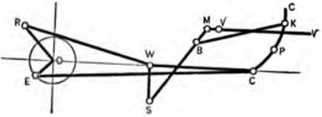


Cam Cut-off Added to Link Motion—Rogers, 1856.

Vanderbilt Boiler.—See Boiler, Vanderbilt.

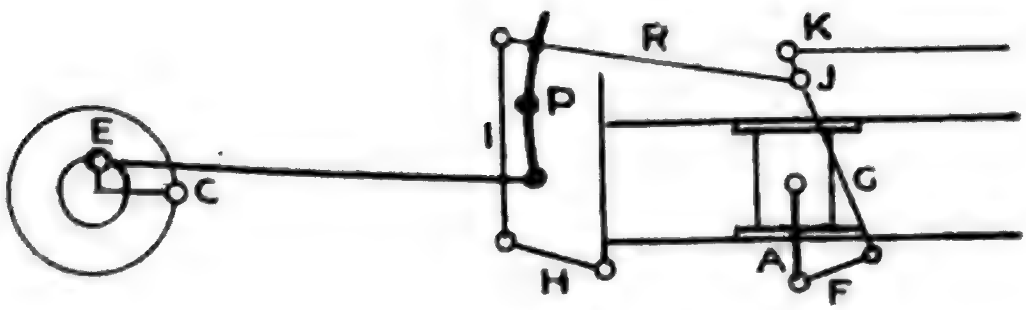
W

Waldegg (Hensinger von) Gear.—Only one eccentric but complicated. Eccentric rod E. C, main rod R W. Rod M S connects with crosshead and valve rod similarly to the Walschaert. Position of radius rod B K controls cut off.



Walschaert Gear.—A single eccentric or return crank and crosshead connection. Eccentric at right angles to crank. Link swings from center, and is controlled by eccentric. This gives travel to valve while the crosshead

connection controls lead. For this reason they have constant lead. This motion is all outside and is especially adaptable to freight engines, where there is little room underneath. Invented by German in 1844. Takes motion from return crank or eccentric and from cross-head.



Walschaert Valve Gear.

A—Cross-head connection, B—Main crank pin, E—Return crank, F—Connecting link, G—Arm to valve rod, H I—Arms controlling Radius rod P, J K, Converting points on valve rod.

Water Bars.—A form of grate used on some roads for anthracite coal. The grate consists of tubes connected to the water space front and back of firebox. Water is supposed to circulate through them, but they burn out at intervals. About every fifth bar is made of solid round iron to be pulled out in dumping fire. Have been used at intervals for years. Very little used now.

Weight of Water per Cubic Foot and Heat Units in Water between 32° and 212° F.											
Temperature, Degrees F.	Weight in Pounds per Cubic Foot.	Heat Units.	Temperature, Degrees F.	Weight in Pounds per Cubic Foot.	Heat Units.	Temperature, Degrees F.	Weight in Pounds per Cubic Foot.	Heat Units.	Temperature, Degrees F.	Weight in Pounds per Cubic Foot.	Heat Units.
32	62.42	0.00	78	62.25	46.03	124	61.67	92.17	170	60.77	138.45
34	62.42	2.00	80	62.23	48.04	126	61.63	94.17	172	60.73	140.47
36	62.42	4.00	82	62.21	50.04	128	61.60	96.18	174	60.68	142.49
38	62.42	6.00	84	62.19	52.04	130	61.56	98.19	176	60.64	144.51
40	62.42	8.00	86	62.17	54.05	132	61.52	100.20	178	60.59	146.52
42	62.42	10.00	88	62.15	56.05	134	61.49	102.21	180	60.55	148.54
44	62.42	12.00	90	62.13	58.06	136	61.45	104.22	182	60.50	150.56
46	62.42	14.00	92	62.11	60.06	138	61.41	106.23	184	60.46	152.58
48	62.41	16.00	94	62.09	62.06	140	61.37	108.25	186	60.41	154.60
50	62.41	18.00	96	62.07	64.07	142	61.34	110.26	188	60.37	156.62
52	62.40	20.00	98	62.05	66.07	144	61.30	112.27	190	60.32	158.64
54	62.40	22.01	100	62.02	68.08	146	61.26	114.28	192	60.27	160.67
56	62.39	24.01	102	62.00	70.09	148	61.22	116.29	194	60.22	162.69
58	62.38	26.01	104	61.97	72.09	150	61.18	118.31	196	60.17	164.71
60	62.37	28.01	106	61.95	74.10	152	61.14	120.32	198	60.12	166.73
62	62.36	30.01	108	61.92	76.10	154	61.10	122.33	200	60.07	168.75
64	62.35	32.01	110	61.89	78.11	156	61.06	124.35	202	60.02	170.78
66	62.34	34.02	112	61.86	80.12	158	61.02	126.36	204	59.97	172.80
68	62.33	36.02	114	61.83	82.13	160	60.98	128.37	206	59.92	174.83
70	62.31	38.02	116	61.80	84.13	162	60.94	130.39	208	59.87	176.85
72	62.30	40.02	118	61.77	86.14	164	60.90	132.41	210	59.82	178.87
74	62.28	42.03	120	61.74	88.15	166	60.85	134.42	212	59.76	180.90
76	62.27	44.03	122	61.70	90.16	168	60.81	136.44			

Water.—One cubic inch weighs .036 pounds. One cubic foot at 32° Fahr. weighs 62.4 pounds and contains 7.4 U. S. gallons. One U. S. gallon contains 231 cubic inches and weighs 8 1-3 pounds. One Imperial gallon contains 277¼ cubic inches and weighs 10 pounds.

Water Brake.—Sometimes called Le Chatelier brake, from its designer. Cylinder cocks are opened, engine is reversed and a small amount of water drawn by special piping just over the crown sheet is admitted to exhaust passages in saddle. This flashes into wet steam and prevents cinders being drawn into cylinders, which would cut them. The engine being reversed, the pistons act as air compressors and exert a great holding or braking power on the locomotive. Used on either simple or compounds on the very mountainous roads of the West.

Water Groove Packing.—A plan where one or more grooves are turned in a piston or bored in a gland or packing box. Condensed steam collects in these grooves and makes a seal or packing.

Water Pressure Governor.—A device to regulate the flow of air into the storage reservoir for raising water in Pullman and other cars.

Water Used by Locomotive.—Mallet compound on B. & O., weight, 479,500 lbs.; drawbar pull, 74,000 lbs.; compound, 84,000 lbs.; simple uses. 152 gallons or 1,267 lbs. per mile—5.9 lbs. of water per lb. of run of mine coal.

Water Tanks.—Should have large discharge openings so as to avoid delaying trains. Chicago and Northwestern Railway uses many

tanks 24 feet in diameter and 16 feet high, on towers 16 feet high. These have 14-inch supply pipes and 12-inch delivery, which will deliver 4,000 gallons per minute. Some even reach 5,000 gallons per minute.

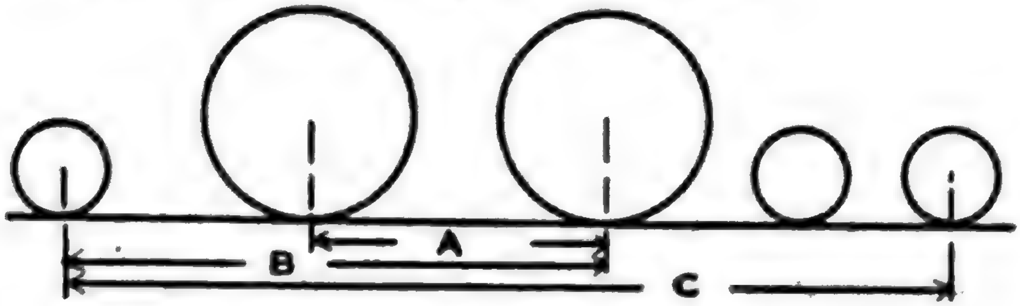
Water Tanks.—As these vary in the amount of taper given the sides, it is perhaps easier to calculate each case than attempt to give a table. Measure the diameter in feet 4-10 the height from the large end and call this diameter. Square this and multiply by .7854 by the height and by 7½, and the answer gives the number of gallons the tank will hold.

If the tank is 15 feet high, measure the diameter 4-10 of this, or 6 feet from the big end. Call this diameter 10 feet. Then $10 \times 10 = 100 \times .7854 = 78.54$. Multiply this by 15, and it gives 1178.1 cubic feet. $1178.1 \times 7\frac{1}{2} = 8835.7$ gallons in tank. Or use any table, measuring the diameter as above.

Wear of Rails.—This, of course, varies under different conditions, such as grades and curves and including the breaking action of wheels. French roads claim that the wear at points where all trains stop is five times as great as at other stations. The life of rails is estimated at from 100 to 250 million tons of traffic over them. On excessive curves and grades, such as 9 degrees on a rise of 2½ per cent., or 636 feet radius and 116 feet to mile, the life is estimated from data obtained at only 10 million tons.

Wheels.—Cast wheels for 100,000 lb. car should weigh 700 pounds; 80,000 lb. car 650 pounds; 60,000 lb. car 600 pounds. Minimum thickness of chill ⅜ of an inch.

Wheel Base.—Distance from center of front wheel to center of rear wheel. See driving wheel base and rigid wheel base.



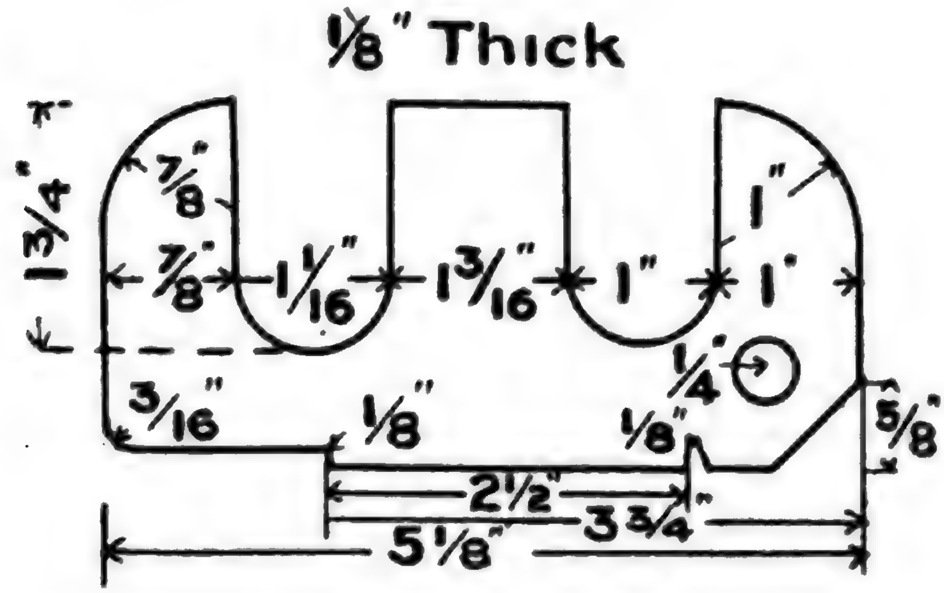
Wheel Base.—Length between wheel centers.

A = Driving wheel base.
B = Rigid wheel base.
C = Total wheel base.

Wheel Defect Gage.—Use of.—

A—Gaging flat or shelled spots in tread of wheel; must not exceed 2½ inches.

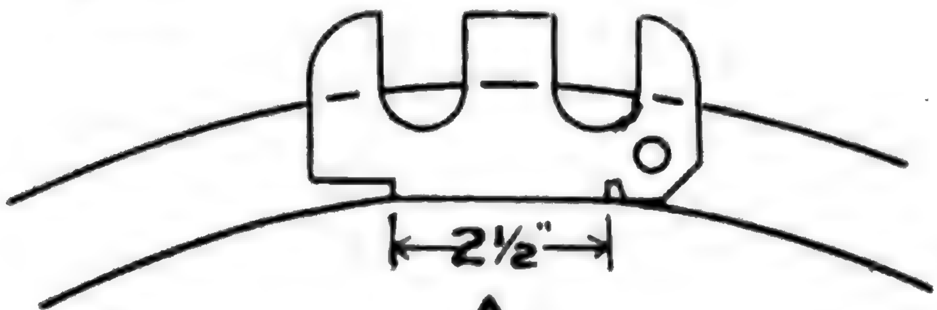
B—Gaging worn flanges. Cars under 80,000 lbs. capacity must not have flanges less than 1 inch thick; over 80,000 lbs., 1 1-16 inches.



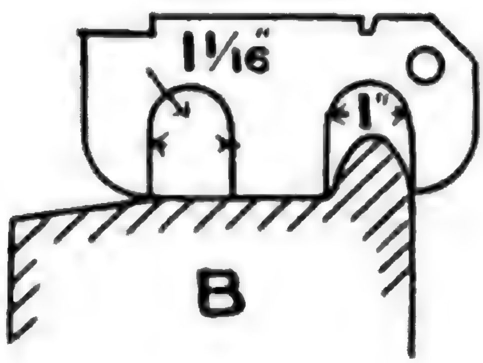
Wheel DefectGage.

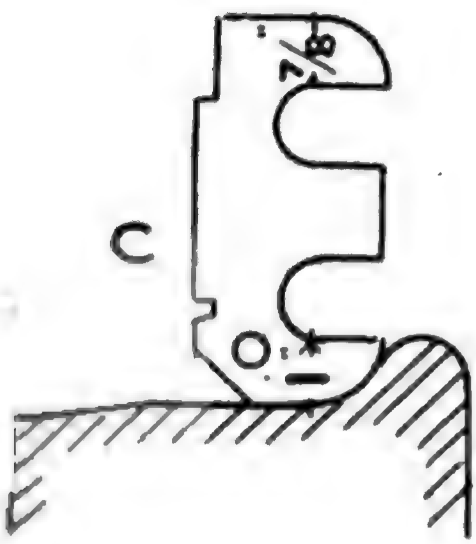
C—Gaging worn flanges. Wheels under less less than 80,000-lb. cars, 1 inch; over 80,000 lbs., ⅞ inch from tread.

D—Gaging chipped rims. Measured ⅝ inch from tread must not be less than 3¾ inches.



A





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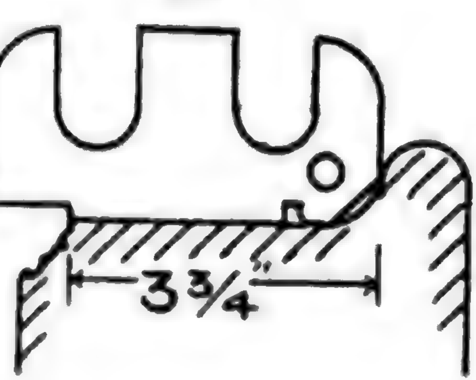
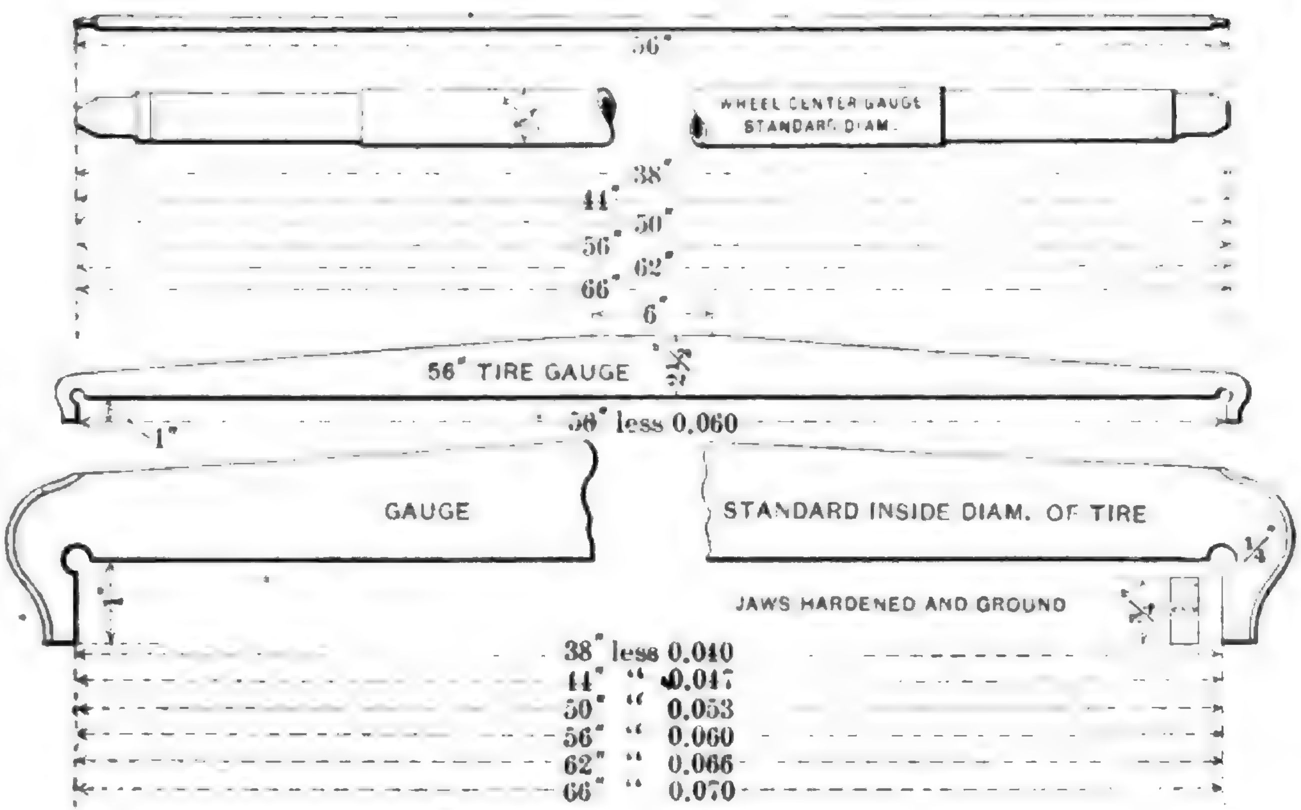
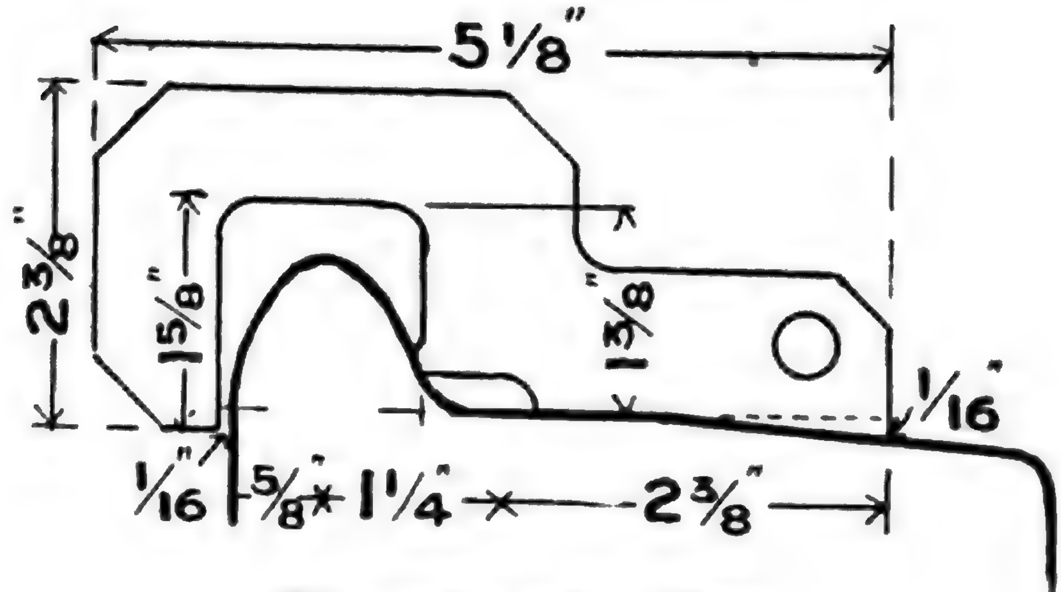




Standard Locomotive Wheel-center and Tire Gauges—Adopted by the American Railway Master Mechanics' Association, June, 1886.—

The standard diameters of the six sizes of centers and tires proposed by the committee, and adopted by the association, are as given, the amount less for each size being the shrinkage allowance for boring tires, which, while insuring a tight fit, avoids the danger of excessive shrinkage strains additional to those required to withstand actual service.

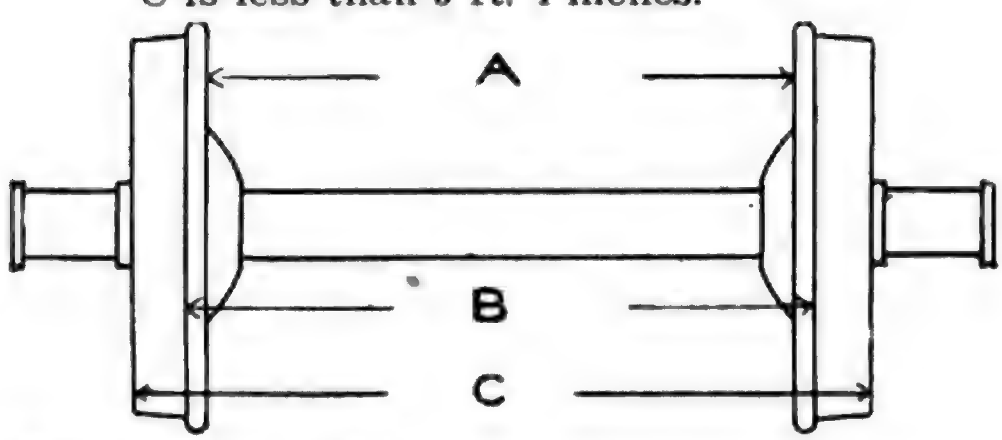


Flange Gage for Tires.

Wheels.—Gage of.—

Wheels cast after August 31, 1894, are out of gage if

A is less than 4 ft. 5¼ inches
B is more than 4 ft. 6¾ inches
C is less than 5 ft. 4 inches.



Wheels for Cars.—

33″ freight and passenger cars.

	60,000 lb. cars and less.	70,000	100,000	36″ cars	Tenders
M	500-560	610-650	670-720	680-705	720-760
Drop, ft.	12	12	12	12	12
Blows	10	12	15	12	15

C. B. Dudley, P. R. R.

Wheel Centers.—Sargent Co. Steel.

44″	Main......2040 lbs.		48″	...........1485 lbs.	
	F. & B.....1800 "				
50″	Main......1772 "		52″	Main......1770 "	
	F. & B.....1560 "			F. & B.....1570 "	
56″	Main......1913 "		57¾″	Main......1650 "	
	F. & B.....1715 "			F. & B.....1550 "	
60″	...........1700 "		2″	...........1865 "	
66″	...........2500 "		66″	...........2062 "	
66″	Main......1900 "		666″	Main......1900 "	
	F. & B.....1745 "			F. & B.....1725 "	

Wheels.—Chilled. Wheels cast in an iron mould at outer rim or tread of wheel. This chills or hardens that portion making it wear longer in contact with rails.

Wheels.—Cost of.

Solid rolled steel wheels—pair		$54.
Four turnings and removals		4.80
Scrap value		8.75
Net cost	$50.05	
Mileage, 350,000 = cost per 100 miles		.143
Chilled wheels—pair		18.00
Boring, mounting, etc.		1.40
Scrap value	$5.80. Net cost	13.60
Mileage, 80,000—cost per 1000 miles		.17

Wheel Fit.—That part of the axle and the wheel which fit together.

Wheel Fit—Enlarged.—The end of axle (carrying the wheel) is enlarged over the diameter of the bearing to increase the strength and make up for the keyway which is cut out.

Wheels—Paper.—Wheels made by riveting a center of compressed paper between two plates of steel. The hub is of iron or steel, and a steel tire is also put on, so that the paper car wheel is only paper in center.

Wheel Truing Brake Shoes.—Brake shoes having pieces of hard steel or emery inserted to grind or cut off high spots from wheels and keep them true. Some are to be used constantly to keep wheels true—others only after they are worn to true up again.

Wiredrawn Steam.—See Steam Wiredrawn.

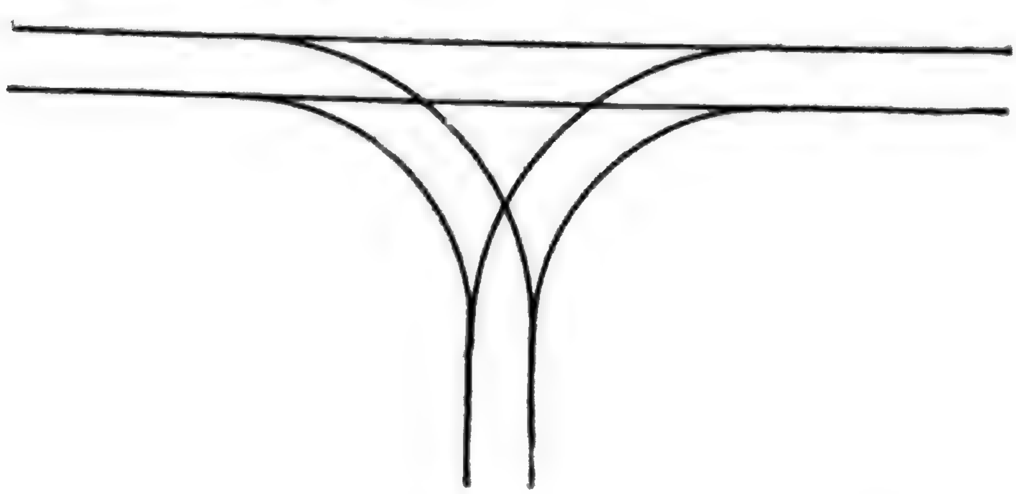
Wooton Boiler.—See Boilers.

Working Pressure.—Pressure carried on boiler. Varies from 140 up to 235 lbs. per sq. inch.

Wrist Pin.—Same as cross head pin.

Y

Y or Y Track.—An arrangement for switching or turning engines without a turntable. Two tracks run off the main line and unite in a Y as shown.



Yield Point.—Force applied at which the material begins to yield or part. In forgings of low carbon steel this is about ½ the tensile strength. With oil tempered or nickel steel it runs from 60 to 75 per cent. of breaking strength.